APPENDIX NOT INCLUDED

# EXPANDED SITE INSPECTION
# PHASE 1 – GROUNDWATER INVESTIGATION REPORT

# FOR

# SAN MATEO CREEK BASIN URANIUM LEGACY SITE
# CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO

Prepared for

**U.S. Environmental Protection Agency Region 6**
1445 Ross Avenue
Dallas, Texas 75202

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# LIST OF ACRONYMS

| | |
|---|---|
| %R | percent recovery |
| aka | also known as |
| ARCO | Atlantic Richfield Company |
| bgs | below ground surface |
| C | Centigrade |
| CDT | Canyon Diablo meteorite |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CERCLIS | Comprehensive Environmental Response, Compensation, and Liability Information System |
| COPCs | contaminants-of-potential-concern |
| D | diluted |
| DO | dissolved oxygen |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| ESI | Expanded Site Inspection |
| F | Fahrenheit |
| Ft/lb | feet per pound |
| GMD | Grants Mining District |
| gpm | gallons per minute |
| GPS | Global Positioning System |
| HASP | Health and Safety Plan |
| HCO3 | Anion Bicarbonate |
| HMC | Homestake Mining Company |
| HRS | Hazard Ranking System |
| HUC | Hydrologic Unit Code |
| ICP | inductively coupled plasma |
| IDW | Investigation-Derived Waste |
| IRMS | Isotope Ratio Mass Spectrometry |
| Kmb | Mancos Shale |
| LCS | Laboratory Control Sample |

## LIST OF ACRONYMS (CONTINUED)

| | |
|---|---|
| LM | Legacy Management |
| LSM | lower San Mateo |
| MCL | Maximum Contaminant Level |
| MDC | minimum detectable concentration |
| MDL | method detection limit |
| mg/L | milligrams per liter |
| MOU | Memorandum of Understanding |
| mph | miles per hour |
| MREM/YR | millirem per year |
| MS/MSD | Matrix spike/matrix spike duplicate |
| MSL | mean sea level |
| Na | Sodium |
| NELAP | National Environmental Laboratory Accreditation Program |
| NM | New Mexico |
| NMED | New Mexico Environment Department |
| NMEIA | New Mexico Environmental Improvement Agency |
| NMWQCC | New Mexico Water Quality Control Commission |
| NPDES | National Pollutant Discharge Elimination System |
| NPL | National Priorities List |
| NRC | U.S. Nuclear Regulatory Commission |
| ORP | oxidation reduction potential |
| OSE | New Mexico Office of the State Engineer |
| pCi/L | picocuries per liter |
| PDB | PeeDee belemenite |
| PDF | Portable Document Format |
| ppb | parts per billion |
| PRB | Prevention and Response Branch |
| PV | private well |
| PVC | polyvinyl-chloride |
| QA | quality assurance |

## LIST OF ACRONYMS (CONTINUED)

| | |
|---|---|
| QASP | Quality Assurance Sampling Plan |
| RL | reporting limit |
| RPD | relative percent differences |
| RI/FS | Remedial Investigation and Feasibility Study |
| SC | specific conductance |
| SCDM | Superfund Chemical Data Matrix |
| SI | Site Inspection |
| SMC | San Mateo Creek |
| SMOW | Standard Mean Ocean Water |
| SPLP | Synthetic Precipitation Leaching Procedure |
| START | Superfund Technical Assessment and Response Team |
| TDD | Technical Direction Document |
| TDS | total dissolved solids |
| TM | Task Monitor |
| USCS | Unified Soil Classification System |
| USGS | U. S. Geological Survey |
| WESTON | Weston Solutions, Inc. |
| XRD | X-Ray diffraction |
| YJD | Yellow Jacket Drilling Services, LLC |

# 1 INTRODUCTION

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START-3) contractor, was tasked by the U.S. Environmental Protection Agency (EPA) Region 6 Prevention and Response Branch (PRB) under Contract Number EP-W-06-042, Technical Direction Document (TDD) Nos. 35/WESTON-042-14-001 and 19/WESTON-042-13-001, and the authority of the Comprehensive Environmental Response, Compensation, and Liability Act as amended (CERCLA), to conduct an Expanded Site Inspection (ESI) at the San Mateo Creek Basin Legacy Uranium Site (Site) located near Grants, Cibola and McKinley Counties, New Mexico. A Site Location Map is included as Figure 1-1. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number assigned to the Site is NMN000606847. START-3 has prepared this report as part of the TDD requirements to describe the field investigation activities, analytical scope of work, summary of findings, and conclusions of the initial phase (Phase 1) of the ESI.

## 1.1 PROJECT OBJECTIVES

The project objectives were to: 1) complete a background water quality study for alluvial groundwater and 2) document a ~~an observed~~ release of contaminants-of-potential-concern (COPCs), including radionuclides of potential concern, to alluvial ground water from legacy uranium mines (or group of mines) located in the Ambrosia Lake Mining Sub-district that discharged mine water to surface drainages within the San Mateo Creek (SMC) Basin. The definition of a release under CERCLA (Section 101(22) is *"[A]ny spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discharging of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant)…"*

~~An observed release to groundwater is established by either chemical analysis or by direct observation (USEPA, November 1992). The minimum requirement for establishing an observed release by chemical analysis is analytical data demonstrating the presence of COPCs at concentrations greater than three times background concentration in a groundwater sample~~

~~potentially attributable to the Site. Groundwater samples are collected and analyzed to determine whether the concentration of a COPC is greater than three times the background concentration in order to determine if an observed release has occurred.~~ As part of the Phase 1 groundwater investigation, groundwater samples were collected from the alluvial water-bearing zones in specific areas of the SMC Basin and analyzed for chemical and radiological constituents to evaluate the ~~observed~~ release determination. The sample analytical results were then compared to EPA Primary and Secondary Drinking Water Maximum Contaminant Levels (MCLs) and the New Mexico Water Quality Control Commission (NMWQCC) groundwater standards for the following COPCs:

EPA National Primary and Secondary MCLs

- Total Uranium – 0.03 milligrams per liter (mg/L)
- Total Selenium – 0.05 mg/L
- Sulfate – 250 mg/L
- Total Dissolved Solids (TDS) – 500 mg/L
- Gross Alpha Radioactivity – 15 picocuries per liter (pCi/L)
- Combined Radium-226 and Radium-228 Radioactivity – 5 pCi/L

NMWQCC Groundwater Standards

- Dissolved Uranium – 0.03 milligrams per liter (mg/L)
- Dissolved Selenium – 0.05 mg/L
- Sulfate – 600 mg/L
- Total Dissolved Solids (TDS) – 1,000 mg/L
- Combined Radium-226 and Radium-228 Radioactivity – 30 pCi/L

The comparison to EPA Primary and Secondary MCLs and New Mexico groundwater standards is discussed in detail in Section 6.0, specifically highlighted in Tables 6-5 and 6-6 provided as separate portable document format (pdf) files with this report.

EPA will use the information obtained during Phase 1 and subsequent phases of the ESI to determine if additional response actions under CERCLA are warranted.

## 1.2 SCOPE OF WORK

The scope of work for this investigation was to locate and characterize the natural background quality of alluvial groundwater and document any ~~observed (~~anthropogenic~~)~~ releases of COPCs from legacy uranium mines and mills to the alluvial aquifer at selected locations within the 321-square-mile SMC Basin. At the start of scoping this project, it was recognized that natural background quality of alluvial groundwater would vary across the basin as the mineralogic composition of the alluvium varied. The mineralogy would reflect the different lithologies and mineralogy of the local bedrock outcrops that supplied detritus to the drainage basin. Therefore, several areas of the SMC Basin were targeted for locating and characterizing alluvial groundwater that may represent background. These areas were located primarily in the higher elevations of the SMC Basin where alluvial groundwater, if present, would be upgradient of legacy uranium mines and mills that could be potential sources of COPCs and other constituents to alluvial groundwater.

At the time of scoping, the central portion of the SMC basin was not targeted for characterizing alluvial background water quality because it was downgradient of many legacy mines and mills with respect to the alluvial groundwater flow direction as well as downstream of these sites along San Mateo Creek, Arroyo del Puerto, and other surface drainages. ~~Therefore, the~~ The nature and extent of potential impacts to the alluvial groundwater in this area of the basin from legacy uranium mining and milling operations were unknown.

Areas of the SMC Basin located downgradient of legacy mines or groups of mines that operated as wet mines[1] were targeted for locating and sampling alluvial groundwater that may have been impacted by the mine water discharge operations.

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[1] The term "wet mine" refers to a mining operation that targeted an ore-bearing formation that was saturated. The underground mine workings were dewatered by pumping, and the collected mine water was discharged to nearby surface drainage features such as arroyos or creeks. After the establishment of state or federal discharge permitting programs (e.g., the National Pollutant Discharge Elimination System (NPDES) permitting program), mine water discharge was regulated and typically required treatment prior to discharge to surface drainages. Prior to that time, mine waters discharges in the Grants Mining District were likely not treated.

Field activities included: exploratory borehole drilling and coring; monitoring well installation, development, and sampling; privately-owned domestic and livestock sampling, and industry well sampling. As part of the exploratory siting of potential drilling locations, a seismic survey was conducted in a limited number of areas to identify the axes of any paleo-alluvial channels in the subsurface that would make optimal targets for the placement of boreholes and monitoring wells. The project scope of work included the following activities:

- Review of available background files.
- Attendance at a scoping meeting with EPA personnel in Dallas, Texas.
- Preparation of a site-specific quality assurance sampling plan (QASP), site-specific health and safety plan (HASP), and investigation-derived waste plan (IDW).
- Preparation of cost estimates and procurement laboratories to conduct chemical, radiological, and geotechnical analysis prior to initiating field activities at the Site.
- Management of field activities including: exploratory drilling and borehole logging; installation of monitoring wells; seismic survey; and collection of soil and groundwater samples.
- Evaluation of alluvial background water quality and geochemistry to determine if ~~an observed~~ a release has occurred and comparison of analytical results to EPA Primary and Secondary Drinking Water MCLs and New Mexico Water Quality Control Commission (NMWQCC) groundwater standards.
- Validation of data and preparation of defensible data validation reports.
- Preparation of residential well results letters, maps, and data tables.
- Preparation of a Phase I Groundwater Investigation Report for the Site to include validated analytical data from the samples collected during the field investigation.

Appendix A includes the EPA-approved QASP, and Appendix B includes the site-specific HASP.

## 1.3 REPORT FORMAT

This report is organized as follows:

- Section 1 – Introduction
- Section 2 – Background
- Section 3 – Environmental Setting

- Section 4 – Field Investigation
- Section 5 – Sample Analyses and Data Validation
- Section 6 – Field Investigation Results
- Section 7 – Conclusions
- Section 8 – References

All figures are included as separate portable document format (PDF) files.

# 2 BACKGROUND

Information regarding the Site location, description, operational history, and ownership is presented in the following subsections.

## 2.1 SITE LOCATION AND DESCRIPTION

The SMC Basin (Hydrologic Unit Code [HUC] 1302020703), by which the boundary of the Site is defined, comprises approximately 321 square miles within the Rio San Jose drainage basin in McKinley and Cibola Counties, New Mexico (NMED, 2012). A Site Area Map is provided as Figure 2-1. This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties which has been extensively mined by the domestic uranium industry. The GMD includes the Ambrosia Lake Mining Sub-district. The terms "Grants Mineral Belt" and "Grants Uranium Region" have been used historically to define an area of uranium deposits extending from Gallup on the west to the western edge of the Rio Grande trough on the east. The principal areas within this belt or region, from west to east, are Gallup, Churchrock, Crownpoint, Smith Lake, Ambrosia Lake, Grants, and Paguate or Jackpile (Kelly, 1963). The GMD and the Site lie within this larger Grants Mineral Belt or Grants Uranium Region. Main access into the Site is provided via New Mexico State Highways 605 and 509.

There are 85 legacy uranium mines with recorded production and four legacy uranium mill sites within the SMC Basin. A Site Plan identifying the location of former mills and mines is presented as Figure 2-2. Many of these legacy mines operated as wet mines where the underground workings were dewatered and the collected mine water was discharged (untreated and treated) to nearby surface drainage features, including San Mateo Creek and Arroyo del Puerto. The average underground mine in the GMD continuously discharged more than 1,000 gallons per minute (gpm) of produced water. Collectively, more than 150 billion gallons of water were pumped from aquifers in the GMD between 1956 and 1982 (Gallaher and Cary, 1986). The mine discharge water infiltrated channel fill sediments and saturated portions of the alluvium and underlying bedrock aquifers along the basin channels. Tailing liquids from the former uranium mills also seeped downward into the alluvium and underlying bedrock aquifers. These mining and milling operations contributed to degradation of the groundwater quality within the basin (Gallaher and Cary, 1986). Analyses of groundwater samples collected from private water wells throughout the basin by the New Mexico Environment Department (NMED) show exceedances of federal drinking water standards and NMWQCC ground water standards for uranium, selenium, and other constituents (NMED, 2012).

## 2.2 OPERATIONAL HISTORY AND OWNERSHIP

Uranium ore was discovered in the Todilto Limestone at Haystack Butte in 1950, and production began prior to mill construction in the area by open-pit mining. Uranium was discovered at Ambrosia Lake in 1955. Downdip drilling from the initial surface discoveries delineated ore bodies within the Jurassic Todilto Limestone Formation and Westwater Canyon Member of the Jurassic Morrison Formation within the Ambrosia Lake Mining Subdistrict. The discovery of large subsurface uranium deposits within the Westwater Canyon Member resulted in the establishment of two-thirds of the active uranium mines in New Mexico within the Ambrosia Lake Mining Subdistrict by 1980; most of these mines were underground room-and-pillar operations at depths averaging 900 feet (NMED, 2012).

The Anaconda Copper Company built the Bluewater Mill northwest of Milan, New Mexico, in 1953 to process ore from the Jackpile Uranium Mine. This mill used a carbonate-leach process with a capacity of 300 tons per day and operated until 1959. An acid-leach mill was operated from 1957 through 1982, reaching a production capacity of 6,000 tons per day in 1978. Atlantic Richfield Company (ARCO) reclaimed the site between 1991 and 1995 for long-term stewardship under the U.S. Department of Energy (DOE) Legacy Management (LM) Program (NMED, 2012). The Bluewater Mill Site was transferred to the DOE LM Program in 1997 for long-term monitoring and surveillance, including monitoring groundwater quality. Monitoring results indicate that the upper two aquifers (alluvium and San Andreas aquifers) are contaminated with mill-related constituents and that groundwater with elevated concentrations of uranium is migrating beyond the site boundary. A groundwater conceptual site model was developed by DOE in 2014 that describes the aquifers and the potential exposure of downgradient groundwater users to mill-related contamination (DOE, LMS/BLU/S11381, November, 2014).

Two mills were built in 1957 at the present Homestake Mining Company (HMC) uranium mill tailing National Priorities List (NPL) site, located about 5.5 miles north of Milan and 4.5 miles east of the DOE Bluewater Mill site, in Cibola County, New Mexico. The first mill closed in 1962. HMC originally owned the second larger mill in a partnership. When that partnership was dissolved in 1981, HMC became the sole owner. Mill production ceased in 1981, but resumed in 1988 to process ore from its Section 23 Mine and the Chevron Corporation Mount Taylor Mine.

In 1974, New Mexico signed an agreement with the U.S. Nuclear Regulatory Commission (NRC), formerly the Atomic Energy Commission, authorizing New Mexico to regulate uranium milling activities under the Atomic Energy Act as an "Agreement State." New Mexico subsequently issued HMC a radioactive materials license for the mill. Elevated levels of selenium were discovered in the alluvial aquifer downgradient of the site by New Mexico and EPA in 1975 and EPA placed the site on the NPL in September 1983, primarily due to groundwater contamination. At that time, HMC began an aquifer protection and restoration program under New Mexico Groundwater Discharge Permit (DP) 200, including groundwater injection and collection efforts. EPA issued a "No Action" Record of Decision for off-site radon in residential subdivisions in September 1989.

In 1986, at the request of the governor, New Mexico returned its regulatory responsibility for uranium mills back to the NRC. NRC subsequently issued Source Materials License SUA-1471 to HMC for the NPL site. The mill was demolished in 1990. The site groundwater restoration project continued pursuant to SUA-1471 and DP-200. In 1993, EPA and NRC signed a Memorandum of Understanding (MOU) establishing the roles, responsibilities, and relationships of the two agencies due to their overlapping authorities. Under the MOU, all activities conducted under the NRC's regulatory authority must allow the attainment of CERCLA requirements. In 2001, HMC merged with Barrick Gold Corporation (NMED, 2012). HMC is currently conducting a CERCLA Remedial Investigation and Feasibility Study (RI/FS) equivalency process for EPA to assess whether site corrective actions are equivalent to a CERCLA-quality remedy.

Kermac Nuclear Fuels Corporation, which was in partnership with Kerr-McGee Oil Industries, Inc., Anderson Development Corporation, and Pacific Uranium Mines Company, built the Kerr-McGee Uranium Mill at Ambrosia Lake in 1957-1958 and operated the mill for nearly 30 years. Quivira Mining Company, a subsidiary of Kerr-McGee Corporation, became the operator of the mill in 1983. Quivira later became Rio Algom Mining LLC and currently BHP Billiton through corporate mergers. From 1985 through 2002, the mill produced uranium concentrate using only recirculated mine water from the Ambrosia Lake area underground mines. The tailing impoundment at the site contains 33 million tons of uranium ore (*sic*) within an area of 370 acres (NMED, 2012). The Rio Algom Mill Site is in the process of meeting the NRC requirements for mill closure and requesting transfer into the DOE LM program for long-term monitoring and surveillance.

Phillips Petroleum Company built a mill at Ambrosia Lake in 1957 and 1958 and began to process ore from the Ann Lee, Sandstone, and Cliffside mines in 1958. United Nuclear Corporation acquired the property in 1963 when the mill closed. United Nuclear Corporation operated an ion exchange system to extract uranium from mine water in the late 1970s to early 1980s. All operations ended in 1982 (NMED, 2012). DOE remediated the site from 1987-1995 as part of the 1978 Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Program and it is designated as the Ambrosia Lake Site under the LM program for long-term monitoring and surveillance.

## 2.3 GRANTS MINING DISTRICT FIVE-YEAR PLAN

In 2010, EPA and other federal, state, and tribal regulatory agencies with the authority and responsibility for protecting human health and the environment released a five-year plan to assess health and environmental impacts of uranium mining and milling in the Grants Mining District (Five-Year Plan). The Five-Year Plan was intended to compile all activities contributing to the identification and cleanup of legacy uranium milling and mining activities in the Grants

Mining District. The participating agencies committed to assessing legacy contamination at structures, surface and groundwater resources, and sediment to eliminate, reduce or manage associated risk to human health and the environment. The agencies established specific objectives to guide this endeavor. The agencies also agreed to coordinate the assessment efforts. The agencies would implement appropriate laws, regulations, and policies within their jurisdiction to accomplish cross-organizational activities. The participating agencies ~~plan to release~~ released a second Five-Year Plan in June 2016. One of the goals of the second Five-Year Plan is to build a conceptual site model as a tool to understand impacts from legacy uranium mining and milling on surface and groundwater systems in the SMC Basin.

## 2.4 STATE OF NEW MEXICO INVESTIGATIONS

NMED representatives conducted a Site Inspection (SI) during the week of March 30, 2009, that involved sampling 28 residential and livestock wells within the SMC Basin north of the HMC site. The location of the wells are depicted on Figure 2-3. The objective of the SI was to evaluate the Site using the Hazard Ranking System (HRS) and the Superfund Chemical Data Matrix (SCDM) to determine if a threat to human health and the environment exists such that further action under CERCLA would be warranted.

The findings were published in the NMED June 2010 Phase 1 Site Investigation Report, San Mateo Creek Legacy Uranium Site. The conclusions presented in the SI Report were as follows:

- All groundwater samples collected for the SI had at least one contaminant concentration exceeding a respective EPA MCL.
- TDS concentrations increased generally from north to south within the sample set.
- Alluvial groundwater samples typically had higher TDS concentrations than samples from bedrock aquifers.
- Areas of relatively elevated nitrate + nitrite concentrations were identified north of the HMC site and near the junction of state highways 605 and 509.
- Dissolved uranium concentrations averaged approximately 58 µg/L for the entire SI sample set.
- Analysis of the hydrochemical data indicated a positive correlation between dissolved uranium and selenium concentrations.

- The highest concentrations of uranium and selenium were found in a presumed alluvial well located in the southern part of the basin north of the HMC site.
- Qualitative analyses suggested that the average concentrations of these analytes are higher than background concentrations.
- The highest activity values for Radium226 (2.90 pCi/l) and Radium228 (3.91 pCi/l) came from SMC-32, which was inferred to be completed in the Morrison Formation and was the closest well sampled downgradient in the alluvial aquifer below numerous legacy uranium mines and two uranium mills.

NMED representatives conducted SI Phase 2 activities on November 8 and 9, 2010, that involved the collection of groundwater samples from three private domestic wells within the SMC Basin and a private domestic well outside of the basin, within the town of Cubero, New Mexico. The objective of the SI Phase 2 was to evaluate the Site using the HRS and the SCDM to determine if a threat to human health and the environment exists such that further action under CERCLA is warranted. The four domestic wells were sampled by NMED at the request of the well owners in response to the ongoing investigation of potential environmental impacts from legacy uranium mine and mill sites within the Grants Mining District. One additional sample (RH11-001A) collected by Roca Honda Resources from the north vent hole at the Johnny M Mine was used by NMED for geochemical interpretation of the hydrogeology in the area of the GMD-04 well and the Johnny M Mine. Figure 2-4 illustrates the location of the wells and vent hole sampled during the SI Phase 2. The ground water samples collected from the private wells were designated as follows:

GMD-01
GMD-02
GMD-03 (Duplicate of GMD-02)
GMD-04
GMD-05

A summary of the analytical results is presented in the NMED document entitled *"Site Inspection Report, Phase 2, San Mateo Creek Basin Legacy Uranium Mine and Mill Site Area, CERCLIS ID NMN000606847, Cibola-McKinley Counties, New Mexico, June 2012"* (Phase 2 SI Report). The findings of the Phase 2 SI Report included the following:

- Gross alpha exceeded the EPA MCL of 15 pCi/L in samples GMD-01, GMD-02, GMD-04, and RH11-001A.
- Combined Radium226 and Radium-228 exceeded the EPA MCL of 5 pCi/L in samples GMD-04 and RH11-001A.
- Uranium exceeded the MCL of 0.030 mg/L in sample RH11-001A.
- Sulfate exceeded the secondary MCL in samples GMD-02, GMD-04, and GMD-05.
- TDS exceedances above the EPA MCL of 500 mg/L included GMD-02, GMD-04, and GMD-05.

NMED representatives returned to the SMC Basin in October 2014 and January 2015 to collect additional groundwater samples from 24 private wells for analysis. The results of this investigation are presented in the September 2015 NMED report entitled "*Site Reassessment Report, Lower San Mateo Creek Basin Site, Cibola and McKinley Counties, New Mexico, CERCLIS ID NMN000606847*".

# 3 ENVIRONMENTAL SETTING

A discussion of meteorological conditions, topography, geologic setting, and site hydrogeology is provided in the following subsections.

## 3.1 METEOROLOGICAL CONDITIONS

At the Grants-Milan, New Mexico Airport the average annual maximum temperature is 61.7° Fahrenheit (F) and the average annual minimum temperature is 34.6° F. The highest maximum average temperature of 83.1° F occurs in July and the lowest minimum temperature of 16.0° F occurs in January. The average annual total precipitation is 8.66 inches. The maximum average monthly precipitation of 2.11 inches occurs in August, and the minimum average monthly precipitation of 0.28 inches occurs in February and December. Average annual snowfall is 9.7 inches, with the maximum snowfall of 3.1 inches occurring in December. Prevailing wind direction is from the northwest. Over the course of the year, typical wind speeds vary from 0 to 21 miles per hour (mph), rarely exceeding 29 mph.

## 3.2 TOPOGRAPHY AND SURFACE HYDROLOGY

The SMC Basin is mainly rangeland within the Colorado Plateau physiographic province. It is characterized by rough, broken terrain, including steep mountainous areas, plateaus, cuestas, and mesas intermingled with steep canyon walls, escarpments, and valleys. Additional topographic features in the area indicate volcanic activity expressed as erosion-resistant volcanic plugs and black-colored basalt capped plateaus and mesas (USDA, 2005).

In the eastern part of the SMC Basin, the headwaters of San Mateo Creek originate on the north flank of Mount Taylor. One branch of the headwaters originates in San Mateo Canyon above the community of San Mateo while another branch drains the San Mateo arch/Jesus Mesa area via Marquez and Maruca Canyons. Within the San Mateo Canyon branch, springs maintain a small perennial flow that is captured in the San Mateo Reservoir, located above the community of San Mateo (USDA, 2005). San Mateo Creek flows west and turns southwest above the NM State

Highways 605 and 509 junction where it continues until it terminates in the vicinity of the HMC site.

The north and northwestern parts of the SMC Basin are drained by the ephemeral network of dry alluvial channels contained in Martin Draw and Hijino Draw. These two drainages pass the now dry Ambrosia Lake shallow depression and the former Rio Algom Mill site and join to form the Arroyo del Puerto. The Arroyo del Puerto continues east and south to the confluence with San Mateo Creek just past the NM State Highways 605 and 509 junction. From this point, surface water flow in San Mateo Creek is southward in the direction of the HMC NPL site.

## 3.3 GEOLOGIC SETTING

The SMC Basin is generally characterized by large faulted, tilted, and eroded ridge-forming sedimentary strata, broad valleys, and a large volcanic complex called Mount Taylor in the northeastern part of the basin. The SMC Basin is located along the southern margin of the underlying San Juan Basin where it is influenced by three regional tectonic features: the Zuni Uplift on the south, the Chaco Slope on the west and north, and the Acoma Sag on the east. The major tectonic and structural geologic feature in the SMC Basin is the centrally located San Mateo Fault Zone. The highest point, Mount Taylor Peak, at an elevation of 11,301 feet, stands approximately one mile above the Rio San Jose 12 miles to the south. The Mount Taylor volcano is part of a larger, northeast-trending volcanic field that includes Mesa Chivato, a broad plateau on the northwest side and Grants Ridge on the southwest side. Basalt that caps Mesa Chivato and other mesas surrounding Mount Taylor makes up about 80% of the volume of the volcanic field (Brod and Stone, 1981).

The general dip of the San Juan Basin sedimentary bedrock units in the study area is toward the north and northeast. The San Mateo Fault Zone is a northeast-southwest trending fault zone within the San Juan Basin that extends from the Zuni Uplift through the HMC NPL site and parallel to NM State Highway 605 until it ends near the Cliffside Mine and the edge of San Mateo Mesa. The fault zone underlies the central portion of the SMC Basin and it likely influenced early drainage features and channel development within the basin. The maximum vertical displacement of the San Mateo fault (with the east side of the fault being downthrown) is estimated to be about 450 feet in the vicinity of the NM State Highways 605 and 509 junction (Brod and Stone, 1981).

The geologic bedrock formations within the San Mateo Creek Basin that are important water-bearing units and aquifers are primarily sedimentary in origin. From south to north across the study area Triassic, Jurassic, Cretaceous, and Tertiary rocks are exposed at the surface. The major aquifers or water-bearing units consist of the Permian San Andres Limestone and Glorieta Sandstone formations, Jurassic Morrison Formation (Westwater Canyon Member), and the Quaternary alluvium. Other aquifer units may include undifferentiated Triassic Chinle Formation, undifferentiated Jurassic and Cretaceous Dakota Sandstone, Mancos Shale, and Mesa Verde Group (Cooper and John, 1968).

Quaternary alluvial material is located primarily along the edge of cliff forming ridges in the lower parts of open valleys and in the longer reaches of eroded channels irregularly located throughout the basin. Alluvial groundwater flow generally mirrors the local topographic surface and flows down slope and mostly in a southern direction. Groundwater flow in the bedrock aquifers is generally north and northeast along the regional flow path toward the central portion of the San Juan Basin. Quaternary alluvium consists primarily of unconsolidated sands, silts, and some clays and gravels with an average thickness of 10 to 80 feet. (Cooper and John, 1968). The occurrence and condition of saturated alluvial material to yield usable quantities of water to a well is a discontinuous, highly variable, and transitory phenomenon in the SMC Basin. Most of the upper SMC Basin alluvium is unsaturated except for some thin and decreasing zones near former and current recharge areas or in the very lower and deeper reaches of the San Mateo Creek and Arroyo del Puerto paleo channels. The greatest thicknesses of saturated alluvial material are found in the vicinity of the HMC NPL site in the southern part of the SMC Basin. A few miles north of the HMC NPL site, the occurrence of saturated alluvium decreases significantly and will continue to decrease since the recharge to surface drainages ended in the mid-1980s when many large uranium mines stopped discharging mine water and closed.

## 3.4 HYDROGEOLOGY AND HISTORICAL WATER QUALITY

A summary of the hydrogeology and historical water quality of the SMC Basin is presented in the following sections.

### 3.4.1 Early Studies by EPA and State of New Mexico

In 1974, the New Mexico Environmental Improvement Agency (NMEIA) (predecessor to the New Mexico Environmental Improvement Division and NMED) requested assistance of EPA Region 6 to assess the impacts of uranium mining and milling activities in the Grants Mining District on surface and groundwater. The results of this cooperative study are documented in the 1975 EPA report entitled "*Summary of Ground-Water Quality Impacts of Uranium Mining and Milling Activities in the Grants Mineral Belt, New Mexico.*" EPA concluded that shallow groundwater contamination was present in proximity to uranium mines and mills and adjacent to surface drainages, and that the contamination was caused by infiltration of effluents from mill tailing ponds, mine discharge water, and effluent discharge from former ion exchange plants.

Based on recommendations made by EPA in 1975, NMEIA, in collaboration with EPA, initiated a water quality monitoring study in the Grants Mining District in 1977. As part of this study, NMEIA installed a network of surface water sampling stations and shallow groundwater monitoring wells in the SMC Basin. The surface water sampling stations were installed along San Mateo Creek and Arroyo del Puerto. The shallow groundwater monitoring wells were constructed along San Mateo Creek, including an upland area in the northeast part of the basin where the alluvium is saturated by natural spring flow and precipitation runoff from the western flank of Mount Taylor. In the northwest SMC Basin, in the Ambrosia Lake area, no upland monitoring wells were installed along the Arroyo del Puerto because the alluvial material was reportedly dry (Bostick, 1985). Even though there is a network of several unnamed drainages in the Arroyo del Puerto upland, the arid conditions, elevation, and low annual precipitation prevent a saturated alluvial system from forming and persisting all year. Figure 3-1 depicts the NMEIA surface water and shallow groundwater sampling locations.

Additionally, NMEIA selected locations for collecting grab samples of precipitation runoff (natural runoff) from storm events and snowmelt to characterize natural surface water quality (Gallaher and Cary, 1986). Runoff sampling locations are also depicted on Figure 3-1.

### 3.4.2 Mine Water Discharge

Beginning in the mid-1950s, the discharge of uranium mine water into the normally dry, intermittent to ephemeral washes created a perennial flow of water in the San Mateo Creek and Arroyo del Puerto channels. This perennial flow was observed to extend downstream in the channels for several miles. The two flows commingled at the confluence of the channels near the junction of NM State Highways 509 and 605 and continued southward along San Mateo Creek. At times, when the creek contained enough flow, it extended past “Deadman’s Curve,” a bend in Highway 605 approximately 3.5 miles south of the San Mateo Creek and Arroyo del Puerto confluence. The perennial flow also extended past the Bert Roundy Ranch located another 1.5 miles south of Deadman’s Curve where dams were constructed to divert/impound some of the creek’s water to promote growth of cattle forage. The stream flow not contained by the dams was observed to continue as far southward as the HMC NPL site tailing impoundment, which was constructed across the former channel of San Mateo Creek (EPA, 1980).

The volume of mine water discharged to these channels constituted billions of gallons of groundwater of variable quality over nearly three decades of active mining. Mine discharge water quality likely varied for several reasons, including:

1. Aquifer water quality varied naturally among the dewatered formations;
2. Life of mine operations changed over time, beginning with convention (room and pillar) underground mining, followed by old stope leaching operations (*in situ* leaching) that included the recirculation of mine water fortified with sodium bicarbonate or sulfuric acid, for secondary uranium recovery;
3. Backfilling of the underground workings with slurried mill tailings at several large mines; and
4. Little to no treatment of the mine water until the late 1970s to minimize the release of toxic trace elements (heavy metals) and radiological constituents.

By the early 1980s, many mines had closed and the remaining mines minimized the amount of mine water discharge by using recirculation and settling-evaporation ponds to treat and store water. By late 1979, a combined discharge rate of approximately 7,400 gpm is cited by Gallaher & Goad (1981) for the Ambrosia Lake-San Mateo area uranium mining operations.

Very little to no systematic monitoring of water quality downgradient of mine water discharge areas was conducted until the mid and late 1970s. The NMEIA water quality monitoring study provided a quantitative assessment of impacts from mine discharge water to surface water and shallow groundwater. The NMEIA results are documented by Gallaher and Cary (1986). Precipitation runoff in the SMC drainages was characterized by trace elements and radionuclides being associated with suspended sediments and precipitates, but mine discharge water was high in the dissolved form of trace elements and radionuclides. The gross alpha activity of mine discharge water was as much as 100 times higher than gross alpha levels in natural runoff and 10 to 40 times higher than shallow groundwater. Dissolved levels of molybdenum, selenium, and uranium levels were also higher in mine water than natural runoff. Occasionally, dissolved levels of arsenic, barium, and vanadium were elevated in mine water compared to natural runoff and shallow groundwater. Since the chemical form of many of the trace elements and radionuclides in the mine water is dissolved, constituents remained in solution and were transported from the surface down to the zone of saturation with little to no attenuation. Uranium decay products like Radium-226 and Lead-210 were elevated in mine discharge waters, but their chemical nature inhibited their solubility and they were removed from the water not far from the discharge point.

### 3.4.3 Hydrologic Relationship between Surface and Groundwater

The discharge of billions of gallons of mine water to the Arroyo del Puerto and San Mateo Creek channels transformed ephemeral surface water flows into perennial flows and dramatically increased the volume of water that recharged the underlying alluvial aquifer. This artificial recharge resulted in the rise of groundwater levels on a regional scale. As part of its water quality study, NMEIA sought to document the hydrologic (and water quality) relationships between surface and groundwater. For the SMC Basin, 12 shallow monitoring wells were constructed in clusters at various locations along San Mateo Creek. The wells, illustrated in Figure 3-1, were located in the northeast portion of the basin (Lee-1 and -2 wells); the NM State Highways 605 and 509 junction area (Sandoval-1, -2, and -3 wells); and the central basin area (Otero-1, -2, -3, and -4 wells and the Roundy-1 well).

The NMEIA results showed a hydraulic connection between surface waters and shallow groundwaters in the SMC Basin (Gallaher and Cary, 1986). The elevations of the unconfined water table surfaces in the NMEIA monitoring wells were directly related to the amount of surface flow in the nearby mine water-dominated stream channel and the season of the year. Heightened stream flows were shown to increase infiltration to the underlying alluvium and rapidly raise groundwater levels. A mine operator reported a rise of nearly 50 feet for an alluvial monitoring well along Arroyo del Puerto from the beginning of mining operations in the mid-1950s until approximately 1980. However, by the early 1980s and later with a steady decline and eventual cessation of mine dewatering, the saturated thickness and extent of the alluvial groundwater system steadily and significantly declined as the source of perennial recharge diminished and stopped.

Gallaher and Cary (1986) also reported that one NMEID monitoring well (Otero-1 well), located across from the entrance to Poison Canyon, showed a dramatic decline in water table elevation in response to the cessation of mine water discharge. During 1978-1982, the water level at Otero-1 fell at a rate of approximately 2 feet per year. In 2014, EPA inspected the Otero well cluster during drilling of nearby borehole C-3 as part of EPA's Phase 1 groundwater investigation. The Otero wells, which were completed to depths ranging from 54 to 72 feet bgs, were dry. The well record for Otero-3 showed the depth to water at the time of well completion in 1977 was 30 feet below top of casing (NM Office of the State Engineer (OSE) Permit No. HC# 70729, B-0415-0-10). The dry Otero wells and the water level measured by EPA at C-3 in 2014 (a depth of 84 feet below top of casing) indicated that the groundwater level in this area of the alluvial system had declined by approximately 55 feet since 1977. It also indicates that the ground water level had risen by about the same amount in response to the large volume of mine discharge water that saturated the alluvium prior to 1977. This rise in water levels is consistent with that reported by the mine operator along Arroyo del Puerto.

In 2008, NMED tried sampling the Sandoval-1, -2, and -3 wells but the wells were either dry or contained insufficient saturated thickness to meet purging requirements for a representative sample of sufficient volume to fill all sample containers. The well depths of the Sandoval wells ranged from 80 to 95 feet bgs. The depth to water at the time of well completions in 1977 ranged from 72-74 feet below top of casing (OSE Well Permit Nos. HC# 70729, B-0415-0-5, -6, and -7).

In comparison to the apparent drain down of mine discharge water in alluvial sediments in the central part of the SMC Basin at C-3, the water levels measured in an alluvial monitoring well (Well R) located approximately a mile north of the HMC NPL site and 3 miles south of C-3 have risen slightly (3-4 feet) since the mid-1990s (HMC 2015). Well R and other HMC monitoring wells are discussed in Section 3.4.4 of this report.

### 3.4.4 Historical Alluvial Groundwater Quality

The Quaternary alluvium consists of mostly sand, silt, and clay with some layers of gravel often near the bottom of paleo drainage channels. The thickness of the alluvium varies spatially but deposits averaging 50-100 feet are common depending on the topography of the underlying bedrock surface that forms the base of the alluvium. Alluvial groundwater is present anywhere from a few feet to approximately 100 feet below ground surface.

Historically, the quality of the groundwater in the alluvial system varied across the SMC Basin. In the northeast part of the basin, the groundwater quality was good, with low concentrations of TDS, because there was an ample amount of annual recharge facilitated by the orographic high of Mount Taylor. The local recharge water and mineralogy of the alluvial material created a groundwater geochemical water type that was dominated by the cation sodium (Na) and the anion bicarbonate (HCO3). The average TDS of alluvial groundwater in the northeast part of the basin was 400 mg/L (Brod and Stone, 1981).

The alluvium in the northwestern part of the basin lacked any low TDS source of perennial recharge water. Without natural recharge, the infiltration of mine discharge water in the drainages saturated the alluvium such that the groundwater was geochemically more similar to mine water than to any natural water. Gallaher and Cary (1986) indicated that the evaluation of the change in alluvial water quality was hampered by the lack of pre-mining groundwater quality data, especially along Arroyo del Puerto. However, Brod and Stone (1981) noted that the general contamination of the alluvial aquifer by mine and mill discharges was indicated by high levels of TDS, chloride, and nitrate.

Brod and Stone (1981) described alluvial groundwater in the Ambrosia Lake area as having a 3,300 mg/L average TDS content south of Arroyo del Puerto and a 5,900 mg/L average TDS content north of Arroyo del Puerto. To the east near the junction of NM State Highways 509 and 605, Kaufmann and others (1975) reported that groundwater in the alluvium associated with San Mateo Creek contained about 700 mg/L TDS above its confluence with Arroyo del Puerto and 2,000 mg/L TDS below the confluence. Additionally, this alluvial groundwater upstream of the creek's confluence with Arroyo del Puerto typically contained about 1 mg/L nitrate, whereas higher nitrate concentrations of 18 and 24 mg/L were reported in wells located downstream of the confluence.

Historically, the levels of uranium, molybdenum, and selenium in alluvial groundwater within the SMC Basin were considered by NMEIA to be impacted by mine dewatering if levels were greater than 0.030 mg/L (uranium) upstream of the San Mateo Creek and Arroyo del Puerto confluence and 0.100 mg/L (uranium) downstream of the confluence[2], 0.030 mg/L (molybdenum), and 0.150 mg/L (selenium), respectively (s*ee* Gallaher and Cary 1986 Report, Section 8.2, p. 101). NMEIA also considered other factors to be indicative of impacts from mine dewatering on alluvial groundwater, including a major change in the TDS level within 3 miles of a mining operation and stratification of water quality (low TDS, non-anthropogenic groundwater

[2] In the 1986 Gallaher and Cary report, the discussion of uranium levels in the alluvial groundwater associated with San Mateo Creek is limited to the 1975 EPA investigation sample results. The 1975 investigation was hampered by the sparsity of alluvial wells to sample. A groundwater sample from a private well near the state highway junction and upstream of the San Mateo Creek and Arroyo del Puerto confluence measured below 0.030 mg/L uranium in 1975 and could be representative of the range of natural uranium levels in the alluvium. However, the 1986 report suggests that natural levels of uranium in the alluvium downstream of the San Mateo Creek and Arroyo del Puerto confluence could be as high as 0.100 mg/L but there was no explanation or substantiation for such a value.

below higher TDS mine water recharge). Table 9.13 (p. 131) of the 1986 Gallaher and Cary report, *Mean Concentrations of Groundwater Constituents Exceeding Use Criteria and Standards*, indicates that levels of molybdenum, selenium, and gross alpha exceeded standards for these parameters at the Sandoval and Otero monitoring well clusters.

Anomolous quantities of molybdenum, selenium, and vanadium were identified within the uranium ore bodies of the Ambrosia Lake Mining Sub-district , including those at the Ann Lee, Sandstone, and Cliffside mines (Granger and others, 1961; Hazlett and Kreek, 1963). Prior to closure, a few Ambrosia Lake area mines were observed to discharge mine water with selenium levels above 1.0 mg/L (Gallaher and Cary, 1986). The Faith Mine, located at the mouth of Poison Canyon in the Todilto Limestone, is reported to have discharged groundwater at a rate of 600 to 900 gpm (*see* paragraph No. 41, 1981 Brod and Stone report). Although no water sample results from the Faith Mine are known to exist, it is possible that the discharge water was elevated in selenium. A groundwater sample collected from a private well (SMC-13) south of Poison Canyon by NMED in 2009 was reported to have selenium at 0.618 mg/L. The possibility that the source of the elevated selenium in alluvial well samples south of Poison Canyon is the discharge water from the Ambrosia Lake area or Faith mines could be considered.

Table 3-1 presents a summary of alluvial and mine discharge water quality data from the 1970s-1980s in the northern portion of the SMC Basin (Gallaher and Cary, 1986).

**Table 3-1**
**Summary of Historical Constituent Values in San Mateo Creek Waters Reported in 1981 and 1986 NMEIA Documents, Grants Mining District, New Mexico**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Date/Source<br>COC | April 1978 to Oct 1980 SMC Upland Alluvial Groundwater (Lee-1 and -2 Wells) | 1981 Mine Discharge Ambrosia Lake Area | 1981 Mine Discharge San Mateo Creek Area | 1980-1982 Raw Mine Water Ambrosia Lake Area | 1977 NM Water Quality Act Groundwater Standard |
|---|---|---|---|---|---|
| **Gross Alpha (pCi/L)** | 2.5 – 15.0 | 580 | 1,100 | 3,050 | Not available (n/a) |
| **Ra-226 (pCi/L)** | 0.05 – 0.33 | 4.6 | 23 | 280 | n/a |
| **Molybdenum (mg/L)** | 0.005 – 0.01 | 0.79 | 0.32 | 1.19 | 1.0 |
| **Selenium (mg/L)** | 0.005 – 0.005 | 0.41 | 0.04 | 0.075 | 0.050 |
| **Uranium dissolved (mg/L)** | 0.005 – 0.010 | 2.4 | 0.08 | 3.82 | 5.0 |
| **Sulfate (mg/L)** | 5-20 | 837 | 205 | 715 | 600 |
| **Chloride (mg/L)** | 3 – 8 | 90 | 10 | n/a | 50 |
| **Total Dissolved Solids, TDS (mg/L)** | 125 -300 | 1,690 | 520 | 1,235 | 1,000 |
| **Arsenic (mg/L)** | n/a | n/a | n/a | 0.021 | 0.100 |

In the central portion of the SMC Basin north of the HMC NPL site, alluvial groundwater quality has been monitored by HMC since 1976 to determine background conditions with respect to the HMC NPL site. Two sets of alluvial wells have been used by HMC to monitor groundwater quality. The first set consists of ten wells constructed by HMC within a mile north of the Large Tailing Pile (LTP). HMC refers to these wells as the "near up-gradient wells" to the NPL site. They are designated as wells DD, DD2, P, P1, P2, P3, P4, Q, R and ND (*see* Figure 3-2). Monitoring began at some of these wells in 1976. The second set of wells consist of five private domestic and livestock watering wells located approxately two to three miles north of the LTP. HMC refers to these wells as the "far up-gradient wells" to the NPL site. They are designated as wells 914, 920, 921, 922 and 950[3,4] (*see* Figure 3-2). The earliest monitoring by HMC was at Well 920 beginning in late 1981. The five private wells were sampled by NMED in 2009 and 2015 and by EPA as part of the Phase 1 groundwater investigation. The locations of the private wells are depicted on Figure 4-1. The EPA analytical results are discussed later on in this report and the NMED results in a separate report (NMED 2015).

Historically, HMC has reported a large areal variability in the alluvial water quality from the near up-gradient and far up-gradient wells over the 40 years of ground water monitoring. The results are documented in annual reports submitted to the NRC, NMED and EPA. NMED has compiled a database of the historical ground water data collected for the HMC NPL site. Based on a review of NMED's database, the earliest water quality data for the far up-gradient alluvial wells show a uranium concentration of 0.008 mg/L at well 920 in late 1981. From 1981 to 1994 however, concentrations of uranium at well 920 trended steadily upward to 0.132 mg/L.

The earliest water quality data from the near up-gradient alluvial wells showed uranium concentrations ranged from 0.010 to 0.093 mg/L at well R in the late 1970s. Well R is located about a mile north of the LTP. At well DD, located a half mile north of the northwest corner of

[3] No geologic boring logs or well construction diagrams were found in the New Mexico Office of the State Engineer's database to confirm that the private wells are actually alluvial wells. However, the relatively shallow depths of the wells suggest that some of them (well 920, 921 and 950) likely are screened in alluvial sediments. The results of subsequent drilling by EPA near these wells in 2015 indicate that others (well 922) may actually be screened in a bedrock formation.

[4] The far up-gradient wells have been given other well identifications by NMED as part of the private well sampling activities within the SMC Basin, including designations SMC-10 through SMC-14.

the LTP, uranium concentrations ranged from 0.076 to 0.180 mg/L in the late 1970s and early 1980s.

The latest annual report, entitled *"2015 Annual Monitoring Report/Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200"* (2015 Annual Report), presents groundwater quality data covering the last 15 years. Concentration versus time plots presented in the 2015 Annual Report show trends in concentrations of COPCs since 2000. Uranium concentrations at the near-up-gradient wells show consistent or slightly decreasing trends, with concentrations ranging from approximately 0.010 to over 0.260 mg/L in various wells. In contrast, selenium concentrations have steadily increased in the two most distal near-up-gradient wells R (from approximately 0.430 mg/L to near 0.700 mg/L) and Q (from approximately 0.220 mg/L to nearly 0.400 mg/L).

A statistical analysis was performed by HMC on the near up-gradient historical groundwater quality data from 1994 to 2004 to determine background water quality and propose a modification to site cleanup standards for several contaminants under the NRC's Source Materials License SUA-1471 and NMED's groundwater discharge permitting program (HMC 2004). HMC proposed the modifications to account for the variability in natural background concentrations. The proposed site standards and background values were reviewed and approved by the NRC and NMED and agreed upon by EPA in 2008. Subsequently, several water quality site standards were approved based on the background statistics for the alluvial aquifer by the NRC through a license amendment. They are depicted in Table 3-2. *See* HMC 2015 Annual Report.

**Table 3-2**
**Approved Alluvial Site Standards Based on Background Levels**
**Homestake NPL Site**

| Constituent | Previous NRC License Site Standard (mg/L) | Previous NMWQCC Site Standard (mg/L) | NRC License Site Standard (mg/L) | EPA National Primary MCL or NMWQCC Groundwater Standard (mg/L) |
|---|---|---|---|---|
| Uranium | 0.040 | 5 | 0.160 | 0.030 |
| Selenium | 0.100 | 0.120 | 0.320 | 0.050 |
| Molybdenum | 0.030 | 1 | 0.100 | -- |
| Vanadium | 0.020 | -- | 0.020 | -- |
| Thorium 230 | 0.300 | -- | 0.300 | -- |
| Sulfate | -- | 976 | 1500 | 600 |
| TDS | -- | 1770 | 2734 | 1000 |
| Nitrate | -- | 12.4 | 12 | 10 |

In 2014 EPA initiated a reassessment of the background water quality study performed by HMC at the request of two environmental groups, the Bluewater Valley Downstream Alliance (BVDA) and the Multi-cultural Alliance for a Safe Environment (MASE). EPA has retained the U.S. Geological Survey (USGS) to conduct a field investigation in 2016 at the HMC NPL site as part of this reassessment. EPA is coordinating this work with the NRC, NMED, DOE and HMC. EPA has also discussed this work with the BVDA, MASE, and the communities near the HMC NPL site.

### 3.4.5 Recharge to Bedrock Aquifers

The Quaternary alluvial sediments associated with the two largest drainages in the SMC Basin, San Mateo Creek and Arroyo del Puerto, have been deposited on Cretaceous, Jurassic, Triassic and Permian age bedrock formations that crop out along the southern margin of the underlying San Juan structural basin (Brod and Stone, 1981). San Mateo Creek is a losing stream system and, depending on the local geology, surface water and alluvial groundwater associated with the creek could drain into adjacent and underlying bedrock units through normal seepage and along faults, fractures, and bedding planes. The prominent San Mateo Fault, which trends northeasterly through the basin and has displacements of up to 450 feet (Brod and Stone, 1981), is a major structural feature that could control groundwater recharge and movement in the bedrock aquifers.

In the Ambrosia Lake area, mine effluent was a significant source of recharge water to the Jurassic Morrison Formation and the Cretaceous Dakota Sandstone (Gallaher and Cary 1986). In the middle and southern parts of the SMC Basin, mine discharge water slowly draining from the San Mateo Creek alluvium was possibly a significant source of recharge to the Triassic Chinle Formation. Tailing seepage from the HMC NPL site impoundments recharged and contaminated three Chinle water-bearing zones where they subcrop under the alluvium (HMC 2015 Annual Report).

Wherever there is hydraulic communication between the base of the saturated alluvium and the surface of the underlying bedrock subcrop, there is likely some recharge. Given that the rate of alluvial water decline mirrored the cessation of mine water discharge, the high permeability and low storage capacity of the alluvium helped facilitate the movement of mine water into underlying bedrock formations.

# 4 FIELD INVESTIGATION

START-3 field investigation activities were initiated October 2014 and completed January 2015. Field activities included completing a seismic survey, drilling, and sampling of exploratory soil borings, coring, alluvial monitor well installation, monitor well development and sampling, and IDW management. Figure 4-1 illustrates a broad overview of well and boring locations including borings drilled, monitor wells installed, and wells sampled as part of the field effort. Detailed illustrations of soil borings, monitoring wells sampled , seismic lines shot, and former mines and mills are included in Figures 4-2 through 4-18.

## 4.1 SEISMIC SURVEY

In November 2014, START-3 subcontracted Bird Seismic Services, Inc. of Globe, Arizona to conduct a high-resolution 2-dimesional seismic reflective survey to map the base of alluvium/top of shallow bedrock surface to identify paleo-alluvial stream channels within the San Mateo Creek basin. This survey was performed to select optimal drilling locations for finding alluvial groundwater. It was recognized that if any significant saturation was present in alluvial sediments, it would be in the deepest portions of the paleo channels. Seismic surveys were conducted across four different drainage systems locations at BG-01, BG-02, BG-06, and N-3.

Each seismic reflection profile was approximately 2,000 feet long and laid out across the four drainage systems in an approximate perpendicular orientation to the surface drainage flow. Data were collected from geophones spaced at 10-foot ground-station intervals. The seismic source was on a 4x4 truck mounted with a United Service Alliance AWD-450 accelerated weight drop, capable of procuring approximately 90,000 feet per pound (ft/lb) of energy. The geophones recorded velocity data for post processing. The Bird Seismic Services Final Report is included in Appendix C.

EPA, START-3, and Bird Seismic Services representatives reviewed the seismic information or “stacks” and selected the drilling locations that appeared to be optimal targets for paleo-alluvial stream channels. Two optimal targets were identified at each location. The Global Positioning

System (GPS) Coordinates and corresponding seismic "stack" locations are included in Table 4-1 below.

**Table 4-1**
**Seismic Survey Summary**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Location | Stack Locations Selected for Drilling | GPS Coordinates |
|---|---|---|
| BG-01 and BG-01A | 186-187 and 151 | 35.46212 / -107.88561 and 35.46117 / -107.88579 |
| BG-02 and BG-02A | 152-153 and 112-113 | 35.44826 / -107.81242 and 35.448223 / -107.813793 |
| N-3 and N-3A | 90-91 and 138 | 35.41850 / -107.84372 and 35.41767 / -107.84394 |
| BG-06 and BG-06A | 76 and 22-23 | 35.35825/- 107.91890 and 35.35829 /- 107.91706 |

## 4.2 DRILLING ACTIVITIES

This subsection describes soil boring advancement and sampling procedures, including monitoring well installation techniques. A total of 30 exploratory alluvial borings totaling 1,401 feet were drilled within the SMC Basin. Of the 1,401 feet drilled, 685 feet were drilled in the upper reaches of the SMC Basin to identify background alluvial groundwater locations. A total depth of 716 feet was drilled to identify potentially impacted alluvial groundwater locations downgradient of former legacy mines and mills. Of the 30 borings drilled, 6 were completed as alluvial monitor wells, 4 of which were completed background locations (BG-03, BG-04, BG-05, and BG-07). Two borings were completed as wells (C-3 and N-3A) in areas downgradient of the former legacy mines and mills.

### 4.2.1 Soil Boring Advancement

Yellow Jacket Drilling Services, LLC (YJD), a State of New Mexico-licensed driller, was subcontracted to conduct the soil boring advancement, coring, monitoring well installation, borehole grouting, and surface completion activities. Monitoring well installation and borehole grouting followed State of New Mexico rules and regulations. State of New Mexico well completion records are included as Appendix D.

Each boring was drilled using an YJD CME-850 track-mounted rig using hollow-stem augers and continuously sampled using a 5-foot-long, split-barrel core sampler through the entire alluvium section to the top of bedrock. Soil classification was conducted by the START-3 geologist according to the Unified Soil Classification System (USCS). The soil boring logs are provided as Appendix E. At the completion of each boring, a determination was made between the EPA Task Monitor (TM) and the START-3 field geologist to install a groundwater monitoring well. If a sufficient volume of groundwater was not encountered in the borehole, no well was installed. If a sufficient volume of groundwater was encountered in the borehole, a well was installed and the appropriate screened interval was based on field observations. All borings were left standing overnight and observed the next day for water before any decision was made to grout the borehole.

At some of the drilling locations, multiple exploratory borings were drilled in close proximity to each other and along a line striking perpendicular to the surface drainage alignment to identify the deepest portion of the alluvial paleo channel (i.e., paleo-channel axis). Seismic surveys were not shot at these drilling locations.

### 4.2.2 Monitoring Well Installation

Each monitoring well installed was constructed of clean unused 2-inch-diameter, Schedule 40, flush-threaded polyvinyl-chloride (PVC) casing and a minimum of 10 feet of 0.010-slotted screen. The annular space around the screen was filled with clean, uniform-sized (20 to 40) Colorado silica sand to a minimum height of 2 feet above the top of the screen. A minimum 3- to 5-foot-thick layer of bentonite pellets was placed immediately above the sand pack and hydrated with potable water. The bentonite pellets were allowed to hydrate for at least 30 minutes before the well was tremie grouted to the surface.

A 5-foot-long, 6-inch-diameter outer protective steel casing with a lockable-hinge cap was installed 2 to 3 feet into the grout seal. A 4-foot by 4-foot concrete pad was installed around the outer base of the protective casing. In some cases, a locking flush-mount completion was installed at the request of the property owner. Well construction information is included in the boring logs (Appendix E).

#### 4.2.3 Plugging and Abandonment

Boreholes that did not produce a sufficient volume of water were grouted according to State of New Mexico guidelines using a mixture of 6 to 8 pounds of bentonite powder per 94-pound bag of Portland cement, mixed with 6 to 8 gallons of water. The boreholes were pressure grouted using a tremie pipe from the bottom to the ground surface.

### 4.3 SAMPLE LOCATIONS

The sample locations selected for this investigation were based on a twofold need to: 1) characterize natural background quality of alluvial groundwater; and 2) document a release of COPCs from legacy uranium mines and mills to the alluvial aquifer.

#### 4.3.1 Background Locations Upgradient of Legacy Uranium Mines and Mills

One of the primary objectives of the investigation was to locate and characterize background alluvial groundwater quality at those locations known to be upgradient of any legacy mine or milling operations within the SMC Basin. Five areas located geographically in the northwest, north, east, southeast, and west parts of the SMC Basin were targeted for exploratory drilling to locate saturated alluvial material for well construction and sampling. These locations were in the higher elevations of the basin where alluvial groundwater, if present, would be upgradient of the legacy mines and mills as well as upstream of arroyos, creeks, and other surface drainages at the mines and mills and represent natural background water quality. The central and southern parts of the SMC Basin were not targeted to characterize background water quality because they were downgradient to many legacy mines and mills within the basin and it was unknown whether areas of unimpacted groundwater existed today[5]. Information regarding the five background locations is provided in the following subsections.

#### *4.3.1.1 BG-01*

Two soil borings (BG-01 and BG-01A) were drilled in the north-northwest section of the SMC Basin along Martin Draw, a valley located in McKinley County at an elevation of approximately 7,000 feet. Figure 4-2 illustrates the seismic line and corresponding boring locations. The soil borings were upgradient of the Section 10 Mine along the north and south side of Martin Draw. During drilling, dry alluvial material was observed until auger refusal occurred which was encountered at an approximate depth of 60 feet below ground surface (bgs). The boring locations were selected based on a review of a seismic line shot in a north-to-south orientation and perpendicular to Martin Draw. No evidence of moisture was observed by the field geologist in any of the samples collected from either boring, and the boreholes were grouted to the surface. The alluvium in Martin Draw was observed to be dry at the time the borings were drilled.

#### *4.3.1.2 BG-02*

Borings BG-02 and BG-02A, shown in Figure 4-3, were drilled in an un-named valley located in the northern section of the SMC Basin approximately 0.5 mile east of Julian Hill and 0.65 mile northeast of the Section 17 Mine at an elevation of approximately 7,100 feet MSL. Both borings were drilled along the seismic line shot in an east-to-west orientation. There are two intermittent creeks noted on the Ambrosia Lake USGS Quadrangle; however, only one dry intermittent creek was observed during the drilling activity. The eastern-most boring (BG-02A) was advanced first through the alluvial layer to a depth of 63.5 feet bgs and terminated at an approximate depth of 72 feet bgs or 8.5 feet, into weathered Mancos Shale. BG-02A was drilled to a maximum depth of 48 feet bgs where Mancos Shale was encountered and drilling was stopped. Neither borings produced water and were grouted to the surface.

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[5] HMC reported that the alluvial water quality north of the HMC NPL site from 1994 to 2004 represents natural background conditions (HMC 2004 Background Study, 2015 Annual Report). However, because EPA had

#### *4.3.1.3 BG-03, BG-04, and BG-05*

The selection of drilling locations BG-03, BG-04, and BG-05 was based on the proximity to San Mateo Creek and Marquez Canyon Creek that receive runoff from Mount Taylor. The Mount Taylor Mine (currently in standby status) is located approximately 1.2 miles east-northeast and upgradient of background locations BG-03, BG-04, and BG-05, and any potential impact to the alluvial and deeper water-bearing formations from operations at this mine is unknown. During mining operations, uranium ore was extracted from depths of over 3,000 feet bgs from ore zones of the Morrison Formation using room and pillar and stope mining methods. Groundwater in the Westwater Canyon Member of the Morrison Formation (ore host rock) at mine level contained concentrations of uranium and radium above the human health standards for drinking water quality. Mine water was reportedly pumped from the mine level to eight lined surface water treatment ponds where ion exchange and barium chloride treatment methods were used to reduce levels of uranium and radium. Six of the eight treatment ponds are clay lined and two ponds are lined with hypalon geomembrane. Treated mine water was reportedly pumped off-site through a 4.3-mile-long, 24-inch pipeline and discharged to San Lucas Canyon under authority of National Pollutant Discharge Elimination System (NPDES) Permit # NM0028100 (Rio Grande Resources, 2010).

BG-03, BG-04, and BG-05 were drilled in an approximate north-to-south orientation between the San Mateo Creek and Marquez Canyon Creek near the village of San Mateo (*see* Figure 4-4). The village of San Mateo is at an elevation of approximately 7,300 feet. Runoff from Mount Taylor discharges to Marquez Canyon and San Mateo Creek and flows east-to-west through the village of San Mateo. A seismic line was not shot at this background location due to the known presence of saturated alluvial conditions created by the runoff and infiltration of San Mateo Creek and Marquez Canon Creek surface water into the alluvial sediments. Saturated alluvial conditions were observed at approximately 45 feet bgs in all three borings and they were converted to background monitor wells. BG-03 was drilled adjacent to the San Mateo Creek to a

decided to reassess HMC's background study, this area of the basin was not included as part of the background evaluation for Phase 1.

total depth of 61 feet bgs and screened from 48 to 58 feet bgs. BG-04 was drilled between San Mateo Creek and Marquez Creek, north of an unnamed tributary, to a total depth of 55 feet bgs and screened from 41 to 51 feet bgs. BG-05 was drilled close to Marquez Creek to a depth of 53 feet and screened from 40 to 50 feet bgs.

#### *4.3.1.4 BG-06*

Soil borings BG-06 and BG-06A were drilled in the western side of the SMC Basin in an unnamed valley approximately 0.65 mile west-northwest of the former Red Point Mine. As shown on Figure 4-5, the borings were drilled east to west along a seismic line shot and perpendicular to an intermittent creek and a small man-made pond. The intermittent creek was observed to be dry at the time the borings were drilled but the pond contained water. The western boring (BG-06) was drilled through the alluvial layer to refusal at a depth of 77 feet bgs. BG-06A was advanced to a refusal that was encountered at a depth of 60 feet bgs. Neither borings produced water and were grouted to the surface.

#### *4.3.1.5 BG-07*

Four background soil borings (BG-07 through BG-07C), shown on Figure 4-6, were drilled in a north-to-south orientation and perpendicular to Lobo Creek in the southern portion of the SMC Basin. Surface water run-off from Mount Taylor discharges to Lobo Creek and other un-named intermittent creeks in the area. Lobo Creek flows mostly intermittent from east to west in the direction of the HMC site. The closest mines to BG-07 are the F-33 Mine and the La Jara and Zia Mines to the south.

Boring BG-07 was advanced through alluvial material until auger refusal at 56 feet bgs. The borehole was allowed to stand overnight as a minimal amount of moist soil was noted by the field geologist during drilling at 45 to 46 feet bgs. The borehole did produce water the following day, and a monitoring well was set and screened from 46 to 56 feet bgs. A static water level measurement was taken after the well was set, and approximately 1 foot of water was recorded in the well. During well development, the well was pumped dry and less than 0.5 gallons of development water was removed. The well was allowed to recover overnight, and approximately 3 inches of water had accumulated in the well. After conversations with the EPA TM and the field geologist, it was determined that the well would not produce enough water to fill all of the sample bottles required for laboratory analyses, and a sample was not collected during the field effort.

START-3 returned to the well BG-07 location and drilled three more exploratory borings identified as BG-07A, BG-07B, and BG-07C in an effort to identify another zone of background alluvial groundwater in the deepest part of the channel axis along Lobo Creek. The three borings were drilled south of the original BG-07 location starting at BG-07A adjacent to Lobo Creek. BG-07A was drilled until auger refusal at 20 feet bgs. BG-07B was drilled approximately 750 feet due north of BG-07A until auger refusal at a depth of 33 feet bgs. BG-07C was drilled approximately 500 feet due north of BG-07B until auger refusal at a depth of 17 feet bgs. There was no evidence of moisture in any of the soil samples collected, and water was not observed the following day after the boreholes were allowed to stand overnight.

### 4.3.2 Sampling Locations Downgradient of Legacy Uranium Mines and Mills

A primary objective was to document an observed release of COPCs from former uranium mines that discharged mine water to soils and sediments in surface drainages. The mine discharge water saturated or significantly re-saturated the alluvium and may have also recharged underlying bedrock aquifers along the San Mateo Creek channel, Arroyo del Puerto, and other un-named drainages. A summary of downgradient drilling locations is summarized in the following subsections.

#### *4.3.2.1 C-3*

As shown on Figure 4-7, the C-3 borehole was drilled adjacent to San Mateo Creek and advanced to a total depth of 94 feet bgs. C-3 is located approximately 900 feet north of Moe No. 4 mine and just south of the state Otero alluvial well cluster that was installed in 1977. The boring was drilled in close proximity to the San Mateo Creek. Saturated soil conditions were observed by the field geologist at 85 feet bgs in coarse gravel and sand. A well was installed and screened from 80 to 90 feet bgs. The static water level was measured at 84 feet below top of casing. During the drilling and installation of alluvial well C-3, the San Mateo Creek was observed to be dry on the surface. The nearby Otero wells (the deepest to 72 feet bgs) were also observed to be dry.

#### *4.3.2.2 C-5*

A total of eight exploratory soil borings were drilled at location C-5 (C-5 to C-5G; Figure 4-8) in close proximity to the Arroyo del Puerto Creek within the central portion of the SMC Basin. This location was selected due to its downgradient position of legacy milling and mining operations to target potentially impacted alluvial groundwater. According to the USGS Dos Lomas Quadrangle, the Arroyo del Puerto is identified as an intermittent creek that intersects the San Mateo Creek approximately 1.0 mile from the NM State Highways 605 and 509 junction. Rio Algom Mill and the Phillips Mill are located approximately 4.0 miles to the north of C-5 area. Six former mines are also located upgradient of C-5 and include Isabella Mine, Spencer Mine, Section 32 and 33 Mines, and John Bully Mine.

The eight boreholes were drilled with total depths ranging from 15 feet bgs (C-5D and C-F) to 51 feet bgs (C-5C). Moisture was not observed in any of the soil samples collected during the drilling operation. Therefore, a monitoring well was not constructed at the C-5 location and all boreholes were grouted. Surface water was not observed in the Arroyo del Puerto during any part of the field investigation.

#### *4.3.2.3 N-1, N-2, N-3, and N-4*

Locations N-1 and N-1A (Figure 4-9) were advanced in an east-to-west direction and perpendicular to Martin Draw. The former Bucky Mine is located approximately 0.5 mile to the north of the N-1 and N-1A locations. Four additional former mines are located approximately 1.5 to 2.0 miles to the north and include Mary No. 1, Section 10, Dysart No. 1 and Dysart No. 2 mines. Boring N-1 was drilled until auger refusal at a depth of 48 feet bgs. No water was observed and the borehole was grouted the next day. A second boring, N-1A, was selected adjacent to Martin Draw and advanced until auger refusal at a depth of 38 feet bgs. The field geologist observed a 4-inch saturated zone at a depth of approximately 20 feet bgs, and the boring was allowed to stand overnight. Upon returning the next day, water was not observed and the borehole was grouted to the surface. During the drilling of N-1, a small amount of water was observed in a man-made culvert crossing over Martin Draw, but it is not known if this accumulation was due to recent rain or actual flow within the creek.

Two borings (N-2 and N-2A), shown on Figure 4-9, were drilled approximately 2.0 miles southeast of borings N1 and N1-A where an un-named tributary to Hijinio Draw passes under NM State Highway 509. The Section 30 West Mine is located approximately 0.5 miles southwest of N-2 and N-2A locations. The Section 19 Mine is located approximately 0.5 miles due north. Borings N-2 and N-2A were advanced to a depth of 25 and 35 feet bgs, respectively. Damp soil was noted by the field geologist at depths of 20 to 25 feet bgs but water did not accumulate in the borehole the next day and both borings were grouted. Water was not observed in Hijinio Draw during the drilling activity.

Locations N-3 and N-3A were drilled generally in a north-northeast to south-southwest orientation along a seismic line shot. Figure 4-9 illustrates the location of the seismic line and two borings drilled at this location. The Section 24 and Section 25 mines are located approximately 0.5 miles northwest and southwest of locations N-3 and N-3A. The north boring (N-3) was drilled through dry alluvial material until auger refusal at 61 feet bgs at the contact with the top of the Mancos Shale. N-3A was advanced approximately 250 feet south of N-3 to a depth of 63 feet bgs where saturated soil was observed by the field geologist at a depth of 56.6 feet bgs, and a well was set and screened from 53 to 63 feet bgs.

N-4 boring (Figure 4-10) was drilled approximately 0.75 miles northeast of the former Phillips Mill. The boring was advanced through dry alluvial material to a depth of approximately 92 feet bgs until auger refusal where the contact with the top of the weathered Mancos Shale was observed. No evidence of water was noted in any of the samples taken throughout the logging of the borehole. The Mancos Shale was cored from 92 to 110 feet bgs. Observations from the field geologist indicated that the Mancos Shale was less weathered with depth. No water accumulated over a 2-day period and the borehole was grouted to the surface.

#### *4.3.2.4 N-5*

Location N-5 (Figure 4-11) was drilled in close proximity to the San Mateo Creek channel and in the vicinity of the former Chill Willis, Marquez, and Hogan Mines. Drilling N-5 adjacent to San Mateo Creek was not possible due to land access restrictions. N-5 was drilled through dry alluvial material until auger refusal was encountered at a depth of 32 feet bgs. No water was observed and the boring was grouted to the surface.

### 4.3.3 SPLP and Mineralogy Soil Samples

In areas where groundwater was not encountered, at-depth sediment samples were collected from selected borings (BG-07-55 feet, C-5B-40 feet, N-1-47 feet, N-2-24 feet, N-4-9 feet, and N-5-32 feet) for Synthetic Precipitation Leaching Procedure (SPLP) and analysis of general chemistry, metals, and radiological parameters. The intent of the at-depth sediment samples submitted for SPLP was to measure the mobility of constituents (e.g., uranium) that may be adsorbed to the sediments and could leach into the groundwater upon being resaturated. The sediment samples submitted for SPLP analysis were from both background soil borings and soil borings in areas where mine water discharges may have saturated alluvial sediments during legacy mining discharge operations. Heavy metals such as uranium in the mine water discharges may have adsorbed onto the alluvial sediment grains before the mine water drained out and the alluvial sediments dried up. The adsorbed constituents could then potentially move back into the suspended and dissolved phases upon re-saturation of alluvial sediments, possibly resulting in elevated concentrations above background in alluvial groundwater. In this case, the alluvial sediment could act as a new anthropogenic source of mining-related contamination. Mineralogy analysis was also conducted on borehole drilling samples to determine crystalline and clay content of the sediment samples.

## 4.4 MONITORING WELL DEVELOPMENT AND SAMPLING

Alluvial monitoring well development and sampling activities techniques are summarized in the following subsections. All groundwater samples were analyzed for total and dissolved metals including mercury; pH; TDS; anions; alkalinity; gross alpha/beta; Radium-226 and Radium-228;

and alpha spectroscopy. Stable isotope analysis was conducted on three groundwater samples from location PV-03. Stable isotope analysis was performed for the ratio of heavier to lighter isotopes of hydrogen, oxygen, carbon, and sulfur against a known standard value and expressed in units of per mille (o/oo). The ratio of $^{2}H/^{1}H$ is expressed as delta deuterium (δD o/oo); the ratio of $^{18}O/^{16}O$ is expressed as delta oxygen-18 ($\delta^{18}O$ o/oo); the ratio of $^{13}C/^{12}C$ is expressed as delta carbon-12 ($\delta^{13}C$ o/oo); and the ratio of $^{34}S/^{32}S$ is expressed as delta sulfur-34 ($\delta^{34}S$ o/oo). Specific analytical methods of analyses are presented in Section 4 of this report (Faure, 1986).

### 4.4.1 Alluvial Monitor Well Development

The newly installed alluvial monitoring wells BG-03, BG-04, BG-04, C-3, and N-3A were developed no sooner than 24 hours after completion using a Monsoon® pump connected to a 12-volt battery. The submersible pump was initially set at the bottom of the well and slowly moved toward the top of the screen to enhance the flow of groundwater through all portions of the screened interval. Dedicated sample tubing was used at each well location to reduce the possibility of cross-contamination between locations. The pump housing and electrical lines were decontaminated between each well location using potable water and non-phosphate soap. Development and decontamination water generated during well development activity was contained in sealed 55-gallon drums and transported back to the EPA soil staging pad located at 500 Elkins Road in Milan, New Mexico (Figure 2-2).

### 4.4.2 Alluvial Monitor Well Sampling

Five newly installed monitor wells were sampled by START-3 following EPA low-flow sampling guidance methods (U.S. EPA, 540/S-95/504, 1996). They are:

BG-03
BG-04
BG-05
N-3A
C-3

The monitoring well locations are depicted on Figure 4-12. They were sampled using a stainless steel Monsoon® XL pump connected to a 12-volt battery and controller. Groundwater samples were transferred directly from the dedicated sample tubing to laboratory-prepared containers. After sample collection, the containers were placed on ice to reduce and maintain the temperature at or near 4 degrees Celsius. Dedicated sample tubing, potable water, and non-phosphate soap were used to decontaminate the pump and electrical leads between each sample location to reduce cross-contamination.

### 4.4.3 Existing Well Sampling

START-3 sampled a total of 15 existing alluvial and bedrock wells as part of the field investigation activities (Figure 4-13). For reporting purposes, START-3 well identifications (IDs) (and alternate well IDs where they are known for the sample location or well) are included. PV is defined as "Private Well". SMC and LSM are defined as "San Mateo Creek" and "Lower San Mateo," respectively.

Of the 15 existing wells sampled, 10 are privately owned wells used for domestic, livestock watering, or irrigation purposes. They are as follows:

PV-01 (aka LSM-7)
PV-02 (aka SMC-30)
PV-03 (aka LSM-61/SMC-20)
SMC-09 (aka LSM-36)
SMC-10 (aka LSM-35)
SMC-11
SMC-12
SMC-13
SMC-14
SMC-26

The other five existing wells sampled are industry monitoring wells. They are as follows:

907
928
943
MW-35-8
MW-35-9

Table 4-2 identifies the well ownership (private, industry or city) and use (monitoring, domestic, livestock watering, or irrigation) for each well sampled. The locations of monitor wells 907, 943, and 928, designated as San Andres/Glorieta wells, are illustrated on Figure 4-14. The locations of monitor wells MW-35-8 and MW-35-9, designated as alluvial wells, are depicted on Figure 4-15. Private Wells SMC-10, SMC-11, SMC-12, SMC-13, SMC-14, and PV-01 (aka LSM-7) are shown on Figure 4-16. Private well PV-02 (aka SMC-30), along with alluvial monitoring wells BG-03, BG-04, and BG-05 are shown on Figure 4-17. Private wells PV-03 (aka LSM-61 and SMC-20) and SMC-26 are presented on Figure 4-18. Private well SMC-09 is depicted on Figure 4-1.

**Table 4-2**
**Well Ownership and Type**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| WELL ID | WELL OWNERSHIP | WELL TYPE |
|---|---|---|
| PV-01 | Private | Domestic |
| PV-02 | Private | Domestic |
| PV-03 | Private | Domestic |
| 907 | Industry | Irrigation |
| 928 | Industry | Monitoring |
| 943 | Industry | Monitoring |
| SMC-09 | Private | Livestock |
| SMC-10 | Private | Monitoring |

| | | |
|---|---|---|
| SMC-11 | Private | Livestock |
| SMC-12 | Private | Livestock |
| SMC-13 | Private | Monitoring |
| SMC-14 | Private | Monitoring |

For wells that contained dedicated submersible pumps (PV-01, PV-02, PV-03, 907, 943, SMC-09, SMC-11, SMC-12 and SMC-26), groundwater samples were taken after the well had run for approximately 10 minutes at a rate of 1 to 2 gpm to allow clearing of the piping system and to allow for a fresh groundwater sample to be taken.

Monitor wells MW-35-8 and MW-35-9 contained a dedicated bladder pump, and the sampling of these wells was coordinated with the owner's representatives who supplied the necessary equipment for sample collection. START-3 and the owner's representatives collected split samples of these two wells for their respective project and data management needs.

Wells SMC-10, SMC-13, and SMC-14 did not contain dedicated pumping equipment and were sampled using low-flow sampling methods as described above. Sampling of wells SMC-13 and SMC-14 was coordinated with owner's representatives and split samples of each of these wells were taken for laboratory analyses.

START-3 collected field parameters using a pre-calibrated YSI Model 600XL water quality meter to check well stabilization parameters prior to collecting the water sample. In wells where no pump was installed, START-3 measured the depth to groundwater and total depth using a water-level meter. For wells where dedicated pumps were installed, no groundwater measurements were collected. Field parameters were recorded in the site logbook and field data sheets. Stabilization was reached when the following readings were achieved:

- pH was within 0.1 or 0.2 of a standard unit;
- Temperature was within 0.2 degrees Centigrade (C) or 3%;
- Specific conductance (SC) was within 5% for values equal to or less than 100 micro-Siemens and 3% for values greater than 100 micro-Siemens;
- DO (dissolved oxygen) was within 10%; and
- ORP (oxidation reduction potential) was within 10 millivolts.

A summary of water quality measurements collected from START-3 sampled wells is included in Appendix F.

Following sample collection, each sample was labeled, placed in individual plastic bags, and placed on ice in a cooler. All samples were shipped for overnight delivery via Federal Express to a National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory for analyses. Specific laboratory information is included in Section 5 of this report.

## 4.5 INVESTIGATION-DERIVED WASTE MANAGEMENT

Non-dedicated equipment used during drilling activities was decontaminated using high-pressure steam cleaning prior to drilling and between each location. In addition to steam cleaning between drilling locations, the core barrel sampling equipment was high-pressure steam cleaned between each location. This equipment was rinsed with potable water before reuse. Decontamination activities were conducted at a temporary decontamination space constructed at each drilling location.

The fluids and excess soil generated as a result of equipment decontamination was containerized and transported back to the EPA soil staging pad. Water generated from the monitor well installation and development activities was containerized and transported back to the soil staging pad and used to support dust suppression measures. An estimated 5 cubic yards of soil was generated during drilling operations and stored at the soil staging pad. This material was managed with soil generated during excavation activities under EPA TDD No. 1/WESTON-042-14-031 for Removal Action. As part of the EPA Removal Action, all soil was characterized, profiled, manifested, and loaded into trucks and transported off-site for disposal at the Clean Harbors Deer Trail, LLC Disposal Site in Deer Trail, Colorado.

# 5 SAMPLE ANALYSES AND DATA VALIDATION

START-3 conducted sample analyses, data validation, and data management as part of the project activities. These tasks were conducted in accordance with START-3 October 2014 San Mateo Creek Basin Uranium Legacy QASP (Appendix A). Information regarding laboratory analyses, data validation, and data reporting tasks are discussed in the following subsections.

As part of the overall sampling effort, START-3 collected a combined total of 24 groundwater samples and 5 soil samples (including field duplicate samples) for laboratory analyses. START-3 utilized a standard data management system that includes the use of bound field logbooks, sample management and tracking procedures, document control, and inventory procedures for both laboratory data and field measurements. SCRIBE software was used to track sample information and generate report tables for inclusion into this report.

## 5.1 LABORATORY ANALYSES, DATA VALIDATION, AND DATA REPORTING

The supporting laboratories and analytical methods utilized are summarized in the following subsections.

### 5.1.1 Test America Laboratories, Inc.

START-3 subcontracted Test America Laboratories, in St. Louis, Missouri, to analyze a total of 24 groundwater samples for the following methods:

- SW846 Method 6010C
- Total and dissolved mercury by SW846 Method 7470A
- pH by EPA Method 150.1
- Total dissolved solids (TDS) by EPA Method 160.1
- Anions (bromide, chloride, fluoride, nitrate as N, nitrite as N, orthophosphate, and sulfate) by EPA Method 300 or 9056A
- Alkalinity by EPA Method 310.1
- Gross alpha/beta by EPA Method 9310
- Radium-226 by EPA Method 9315
- Radium-228 by EPA Method 9320

- Alpha spectroscopy by Method A-01-R

Five soil samples were collected and prepared for SPLP using procedures specified in SW-846 Method 1312. Samples were prepared and analyzed for anions (bromide, chloride, fluoride, nitrate as N, nitrite as N, orthophosphate, and sulfate) using the procedures specified in SW-846 Method 9056A.

A complete set of Test America Analytical Reports is included in Appendix H.

### 5.1.2 ALS Environmental Laboratories

ALS Environmental Laboratories, in Fort Collins, Colorado, was subcontracted to analyze three confirmation groundwater samples collected from location PV-03 designated as PV-03UF, PV-03F, and PV-03DW for the following methods:

- SW846 Method 6020A
- Total and dissolved mercury by SW846 Method 7470A
- pH by EPA Method 150.1
- Total dissolved solids (TDS) by EPA Method 160.1
- Anions (bromide, chloride, fluoride, nitrate as N, nitrite as N, orthophosphate, and sulfate) by EPA Method 300.0 Revision 2.1
- Alkalinity by EPA Method 310.1
- Gross alpha/beta by EPA Method 9310
- Radium-226 by EPA Method 9315
- Radium-228 by EPA Method 9320
- Alpha spectroscopy by Method A-01-R

The analytical report provided by ALS Laboratories is included in Appendix I.

### 5.1.3 Isotech Laboratories, Inc.

Stable isotope analyses were performed on a subset of the groundwater samples (PV-03UF, PV-03F, PV-03DW) by Isotech Laboratories located in Champaign, Illinois by Isotope Ratio Mass Spectrometry (IRMS) method. Stable isotope analysis was performed for the following isotopes:

- hydrogen-deuterium (δD)
- oxygen-18/16 ($\delta^{18}O$)
- carbon-13/12 ($\delta^{13}C$)
- sulfur-34/32 ($\delta^{34}S$)

The Isotech Laboratory Analytical Report is included in Appendix J.

### 5.1.4 DCM Science Laboratories, Inc.

DCM Science Laboratories, Inc. in Wheat Ridge, Colorado conducted X-Ray diffraction (XRD) to identify crystalline compounds and bulk mineralogy, including clay separation determination for seven soil samples collected from borings C-3, BG-07, C-5B, N-5, N-1, N-2, and N-4. The DCM Science Analytical Report is included in Appendix K.

## 5.2 DATA VALIDATION

START-3 performed data validation for the Test America and ALS Laboratories data packages in accordance with the EPA data review guidance documents (U.S. EPA, 2014). A second data package provided by ALS Laboratories and Isotech Laboratories was also validated to determine whether quality control specifications were achieved as per the EPA data review guidance.

START-3 reviewed the data packages to verify that they met the EPA technical requirements and Quality Assurance (QA) guidelines established for the respective analytical methods. The following list includes the items evaluated for each laboratory sample delivery group (as applicable):

- The chain-of-custody was reviewed to verify the sample IDs and the analyses requested.
- The sample receipt temperature was reviewed to verify that the cooler temperature was within acceptable range.
- Holding times were reviewed to verify the samples were extracted and analyzed within the required holding time.
- Laboratory blanks were reviewed to determine whether laboratory contamination was present.

- Matrix spike/matrix spike duplicate (MS/MSD) samples were reviewed to determine whether matrix interference was present and to determine if laboratory precision was within the acceptable range.
- Laboratory control samples and/or laboratory control sample duplicates were reviewed to verify the accuracy of the method.
- Surrogate recoveries were reviewed to verify that the recoveries were within the acceptable range.
- Initial calibrations were reviewed to confirm conformance to method acceptance criteria for percent recovery and/or correlation coefficient.
- Continuing calibrations were reviewed to confirm that calibration verification was performed before sample analysis and at the method-specified frequency. The calibration verification percent recoveries were reviewed and compared to acceptance criteria.
- Internal standards were reviewed to verify that the recoveries were within the acceptable range.
- Field duplicates were reviewed to verify that field precision was within the acceptable range.
- Reporting limits were reviewed to confirm that they were adjusted to reflect dilution factors and percent solids, if applicable.
- Sample results were reviewed to confirm that the detected concentration was within the instrument calibration range. If the concentration exceeded the instrument calibration range, the data were reviewed to determine if the sample was re-analyzed at a secondary dilution.
- Calculations were performed for sample results from each analytical package to confirm the final result reported by the laboratory. These calculations consider the result produced by the analytical instrument, sample volume, sample weight, calibration correlations, dilution factor, and percent solids, if applicable.

START-3 Chemical and Radiological Data Validation Reports are included in Appendices L and M, respectively.

## 5.3 CHEMICAL DATA USABILITY

START-3 reviewed the analytical results to verify that the data were acceptable for their intended use in meeting the objectives of the project. Overall, the data are considered acceptable for use with qualifications noted in the respective data tables presented in this report.

START-3 subcontracted Test America Laboratories in Earth City, Missouri, to analyze groundwater samples using SW-846 Method 6010C for inductively coupled plasma (ICP) metals and mercury. Following review of preliminary data packages, the START-3 data validation team observed that the laboratory reporting limit (RL) of 0.26 mg/L for total and dissolved uranium was above the EPA MCL of 0.03 mg/L. Test America Laboratories indicated that in some cases, due to matrix interference or analytes present at high concentrations in the water to be analyzed, samples were diluted to enable the ICP mass spectrometer to run aliquots acceptably. Matrix interferences are attributed to high TDS (sodium, magnesium, potassium, calcium, bicarbonate) and total suspended solids (TSS). For diluted samples, the RLs were adjusted (raised) relative to the number of dilutions to the sample water required by the laboratory analytical procedure. START-3 discussed this issue with the EPA TM and directed the laboratory to reanalyze 22 groundwater samples (including 2 duplicate samples) at a RL below the EPA MCL. Test America Laboratories reported there was sufficient sample extract remaining within the 180-day preservation holding time to re-run the total and dissolved metals following SW-846 Method 6020A with an RL of 0.01 mg/L. A reanalysis of the 22 groundwater samples was performed by Test America Laboratories located in Sacramento, California.

The reanalysis of the 22 groundwater samples following Method 6020A resolved the RL limit issue taking into consideration sample dilution requirements. The groundwater samples reanalyzed following Method 6020A for total and dissolved uranium included: SMC-09, SMC-10, SMC-11, SMC-12, SMC-13, SMC-14, SMC-26, SMC-26 (duplicate sample), MW-35-8, MW-35-9, C-3, N-3A, 943, 943 (duplicate sample), BG-03, BG-04, BG-05, PV-01, PV-02, PV-03, 928, and 907. With the exception of dissolved uranium reanalysis for PV-02, the reanalyzed data have been incorporated in the report data tables with applicable data qualifications. There was an inadequate amount of sample volume to reanalyze PV-02 for both total uranium and dissolved uranium. Therefore, only total uranium was reanalyzed for sample PV-02. All reanalyzed samples met the established holding time limit of 180 days with the exception of SMC-11, SMC-12, SMC-13, and SMC-14 (total and dissolved), which were prepared within 180 days but analyzed less than 24 hours beyond the holding time limit. In four samples (PV-03, N3-A, 928, and 907), the dissolved uranium result is slightly greater than the total uranium result. Possible sources of the differences include that the dissolved fractions for samples PV-03, N3-A, 928, and 907 were prepared at a different laboratory and were prepared approximately two months prior to analysis. These two factors could lead to differences in the results, first from different digestion conditions and secondly from potential concentration of the sample over the two-month period of storage depending on the storage conditions. Samples are typically stored for a period of time by the laboratory while final data packages are prepared and electronic data deliverables (EDDs) are generated. Following final data package and EDD delivery, data loading and data validation followed by data table generation is conducted. The laboratory responded to questions about the discrepancy, indicating that it was not unexpected for the results to differ by 1-2 ppb at a 10× dilution. The difference of 1-2 ppb between the total and dissolved analytical values is greater than expected for laboratory quality. The samples were not qualified for these occurrences or discrepancy in the results.

## 5.4 RADIOLOGICAL DATA USABILITY

START-3 data validation was performed on the Test America and ALS Laboratories analytical reports, and overall, the data are acceptable for use except where noted. Analytical methods employed were alpha spectrometry for isotopic thorium and isotopic uranium, and gas flow proportional counting for Radium226 and Radium228, gross alpha and gross beta.

The analytical methods cited are generally accepted industry methods for the requested radioisotopes. Appropriate tracers for isotopic thorium (Th-229) and isotopic uranium (U-232) were used, and percent recovery (%R) were within tolerances. The suite of LCS included blanks, duplicates, and spikes for all laboratory methods and were within tolerances, except for the matrix spike and duplicate as discussed in the next paragraph. The minimum detectable concentrations (MDC) for most analyses met the requested detection limit and were acceptable, with the exception of the gross alpha and beta analyses. The gross alpha and beta results were correctly coded “G.” The laboratory explained the MDCs for the gross alpha and beta did not meet the specified reporting limit due to high solids content. The requested RLs were 1.0 pCi/g for alpha spectrometry and gas flow proportional counting, 3.0 pCi/L for gross alpha, and 4.0 pCi/L for gross beta.

Current EPA standards for radionuclides in drinking water are: a combined Radium-226 + Radium-228 standard of 5 pCi/L; a gross alpha standard of 15 pCi/L (minus radon and uranium);

a combined standard of 4 millirem per year (mrem/yr) for beta emitters (also used is a 50 pCi/L standard for gross beta, and a 0.030 mg/L standard for uranium).

# 6 FIELD INVESTIGATION RESULTS

This section summarizes the field exploratory drilling results with a focused discussion on the condition of alluvial saturation thickness observed during this phase of the SMC Basin investigation (*see* Table 6-1). A discussion of the determination of an observed release to groundwater is based on the results in Table 6-2 and Table 6-3. The comparison of water sample analyte values against EPA Primary and Secondary MCLs and NMWQCC heath-based standards is contained in Tables 6-5 and 6-6.

## 6.1 SUMMARY OF ALLUVIAL SOIL AND SATURATION THICKNESS

Alluvial saturated and unsaturated thicknesses were determined from the boring logs collected during the exploratory drilling investigation and these data are summarized in Table 6-1. Alluvial deposition in the northern portion of the SMC Basin at location BG-01 along Martin Draw and BG-02 located approximately 0.5 miles east of Julian Hill ranged in thickness from 60 to 72 feet bgs. Prior to drilling, seismic lines were shot at BG-01 and BG-02 to help focus the exploratory drilling and target the deepest portion of paleo-alluvial stream channels as the optimal locations for finding saturation. However, no visible water or soil moisture zones of any significance were observed during the drilling and borehole logging at either of the BG-01 and BG-02 locations.

The selection of background locations BG-03, BG-04, and BG-05 was based on the proximity to Mount Taylor and the fact that surface runoff discharges into the San Mateo Creek and Marquez Canyon channels. The alluvial thickness at these three locations ranged from 53 feet at BG-05 to 61 feet at BG-03 (the deepest boring drilled and closest to adjacent Marquez Canyon). The alluvial saturated thickness was 24 feet at BG-03, 13 feet at BG-04, and 16.5 feet at BG-05.

Soil borings BG-06 and BG-06A were drilled in the western side of the SMC Basin in an un-named valley southwest of Mesa Montanosa approximately 0.25 mile west-northwest of the former Red Point Mine. The alluvium at these two borings was unsaturated. Alluvial thicknesses in BG-06 and BG-06A were observed to range from 60 to 77 feet. No visible water or soil moisture zones of any significance were observed during the drilling and borehole logging at either of these two locations.

The BG-07 through BG-07C exploratory drilling locations were sited west of Mount Taylor where highland runoff discharges to Lobo Creek and other un-named intermittent creeks in the southern part of the SMC Basin. BG-07 boring was advanced through 56 feet of alluvial material until auger refusal. Some moist soil was noted in the 45 to 46 feet bgs interval and a well was constructed based on this depth resulting in approximately 2 feet of saturation upon completion. Further exploratory drilling was conducted and the thickness of the alluvium at locations BG-07A, BG-07B, and BG-07C was measured at 20 feet, 33 feet, and 17 feet, respectively. Unfortunately, no visible water or soil moisture zones of any significance were observed during the drilling and borehole logging at any of the BG-07A, BG-07B, and BG-07C locations.

Location C-3 was drilled adjacent to the main reach of the lower part of San Mateo Creek. The alluvial thickness and saturation at C-3 was measured at 94 feet and 5 feet, respectively. Based on the reported water levels in the nearby Otero well cluster in 1977 (30 feet bgs), the amount of saturated thickness within the alluvium in this part of the basin has dramatically decreased since 1977, with a loss of approximately 55 feet of saturated thickness.

The thickness of the alluvium increases along San Mateo Creek from its headwaters near Mount Taylor (53 to 61 feet at locations BG-03, BG-04, and BG-05) to the central part of basin (94 feet at C-3). However, the thickness of alluvial saturation appears to decrease along San Mateo Creek based on the amount of saturated thickness observed at the BG-03 to BG-05 sites compared to C-3 (13 to 24 feet compared to approximately 5 feet).

The alluvium thickness near the Arroyo del Puerto at locations C-5 through C-5G ranged from 15 to 51 feet with no observable saturation or wet zone. All borings appeared to reach auger refusal at the contact of the alluvium with weathered Mancos Shale.

In the area north of the former Rio Algom and Phillips uranium mills in the Ambrosia Lake area the thickness of alluvial material ranged from 25 feet at N-2 to 92 feet at N-4, but all sites were unsaturated with the exception of N-3A. N-3A was drilled to a depth of 63 feet bgs and upon well completion, 9.5 feet of saturated alluvial thickness was measured in the well.

Existing Rio Algom wells MW-35-8 and MW-35-9, located near the Section 35 Mine and Cliffside Mine, were included as part of the alluvial wells sampled for this investigation. Field data collected during well sampling indicate that MW-35-8 has 5.35 feet of saturation, based on a total depth of approximately 47.10 feet and a static water level measurement of 41.75 feet. The boring for MW-35-9 was drilled to a total depth of 95.0 feet bgs. The lithologies described on the boring log are sand to 80 feet bgs and gravel to 95 feet bgs. Yet the boring log also notes that the "Driller felt bedrock at 70 feet bgs." Casing for MW-35-9 was set to a depth of 72.70 feet. A static water level measurement of 37.90 feet indicates 32.10 feet of saturation. However, if the top of bedrock is not at 70 feet bgs and the sand and gravel observed in drill cuttings to the borehole's total depth of 95 feet actually represents alluvial material, then the saturated thickness at MW-35-9 may be greater than the 32.10 feet.

**Table 6-1**
**Total Alluvial and Saturated Thickness Summary**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Location | Alluvial Thickness (ft.) | Saturated Thickness (ft.) |
|---|---|---|
| BG-01 | 60 | 0 |
| BG-01A | 60 | 0 |
| BG-02 | 72 | 0 |
| BG-02A | 61 | 0 |
| BG-03 | 61 | 24 |
| BG-04 | 55 | 13 |
| BG-05 | 53 | 16.5 |
| BG-06 | 77 | 0 |
| BG-06A | 60 | 0 |
| BG-07 | 56 | 2 |
| BG-07A | 20 | 0 |
| BG-07B | 33 | 0 |
| BG-07C | 17 | 0 |
| C-3 | 94 | 5 |
| C-5 | 22 | 0 |
| C-5A | 25 | 0 |
| C-5B | 42 | 0 |
| C-5C | 51 | 0 |
| C-5D | 15 | 0 |
| C-5E | 42 | 0 |
| C-5F | 15 | 0 |
| C-5G | 16 | 0 |
| N-1 | 48 | 0 |
| N-1A | 38 | 0 |
| N-2 | 25 | 0 |
| N-2A | 35 | 0 |
| N-3 | 61 | 0 |
| N-3A | 63 | 9.5 |
| N-4 | 92 | 0 |
| N-5 | 32 | 0 |
| MW-35-8 | 47 | 5.3 |
| MW-35-9 | 72 | 32.1 |

## 6.2 ALLUVIAL GROUNDWATER SAMPLE RESULTS

A summary of alluvial groundwater sample results is provided in the following subsections.

### 6.2.1 Monitoring Wells Upgradient of Potential Legacy Mine and Mill Sources

Three monitor wells (BG-03, BG-04, and BG-05) were sampled to provide geochemical data to characterize background constituent concentrations in an area of the alluvium near the village of San Mateo. This area was thought to be outside the influence of (upgradient of) legacy mine water discharge operations and former mill sites, with the exception of the Mount Taylor Mine.[6] The analytical results from monitor wells BG-03, BG-04, and BG-05 are summarized in Table 6-2 and Figure 6-1. Table 6-2 also depicts the historical ground water data collected by NMEIA at the two upland alluvial groundwater wells (Lee-1 and -2) for comparative purposes. The Lee-1 and -2 wells were located upgradient of legacy mines and mills and the groundwater data collected from those wells represent background water quality in the upper SMC Basin, near Mount Taylor for that time. The Lee-1 and -2 wells were also located in a separate tributary drainage (El Rito Creek) from the San Mateo Creek drainage and, therefore, would not be downgradient of any potential groundwater contamination sourcing from the Mount Taylor Mine.

[6] The Mount Taylor Mine is located approximately one half mile upgradient to BG-03, BG-04, and BG-05. However, because of the historical mine water discharge operation that conveyed treated mine water to San Lucas Canyon, it was anticipated that the potential impact to the San Mateo Creek alluvial groundwater, if any, would be minimal (*see* Section 4.3.1.3, above). Therefore, EPA opted to install these three monitoring wells in an attempt to characterize natural backgroundwater quality in the eastern part of the SMC Basin. It is noted that identifying suitable drilling locations for characterizing background water quality in the alluvium was difficult considering the number and location of legacy uranium mines and mills and the limited degree of saturation in many parts of the basin.

**Table 6-2**
**Alluvial Groundwater Results**
**Monitoring Wells Upgradient of Potential Legacy Uranium Mine and Mill Sources**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Analyte | BG-03 | BG-04 | BG-05 | April 1978 to Oct 1980 SMC Upland Alluvial Groundwater (Lee-1 and -2 Wells) |
|---|---|---|---|---|
| Sulfate (mg/L) | 76 | 22 | 13 | 5-20 |
| Total Uranium (mg/L) | 0.0027JQ | 0.004JQ | 0.016 | 0.005-0.010[a] |
| Total Dissolved Solids (mg/L) | 620 | 350 | 310 | 125-300 |
| Total Radium (Ra-226 + Ra-228 pCi/L) | 4.74 | 4.98 | 0.49 | 0.05-0.33[b] |
| Gross Alpha (pCi/L) | 51G | 18.2G | 13.5 G | 2.5-15.0 |
| Total Selenium (mg/L) | 0.021U | 0.023JQ | 0.021U | 0.005-0.005 |

[a] Dissolved uranium

[b] Ra-226

Notes:

mg/L – milligrams per Liter; pCi/L – picocuries per Liter; JQ – Analyte was detected at less than the reporting limit; G – the Sample MDC is greater than the requested RL; U – Analyte not detected at or above method detection limit; K – unknown bias.

The results from BG-03, BG-04, and BG-05 show total uranium concentrations ranged from 0.0027 mg/L to 0.016 mg/L. These values represent some of the lowest concentrations for total uranium measured in alluvial groundwater anywhere in the SMC Basin and are below the EPA MCL of 0.030 mg/L. The combined Radium-226 + Radium-228 levels detected at BG-03 (4.74 pCi/L) and BG-04 (4.98 pCi/L) were an order of magnitude above that at BG-05 (0.49 pCi/L), but all three were below the federal MCL of 5.0 pCi/L. Sulfate and TDS concentrations were also among the lowest levels found in the SMC Basin. Sulfate concentrations ranged from 13.0 to 76.0 mg/L and are below the 600 mg/L NMWQCC standard for domestic water supply and the EPA Secondary MCL of 250 mg/L. The TDS concentrations ranged from 310 to 620 mg/L and are below the 1,000 mg/L NMWQCC standard for domestic water supply. The 620 mg/L for TDS at BG-03 is above the EPA Secondary MCL of 500 mg/L. Gross alpha radiation levels ranged from 13.5 to 51.0 pCi/L and exceeded the federal MCL of 15.0 pCi/L at BG-03 and BG-04. Selenium was not detected above the laboratory method detection limit of 0.021 mg/L. When considering the levels detected for the constituents at these three wells, especially the combined Radium-226 + Radium-228 and gross alpha radiation levels, it is uncertain whether these levels represent natural background water quality or anthropogenic impacts for this part of the SMC Basin.

The comparison of the results at BG-03, BG-04, and BG-05 to the historical data collected by NMEIA at the upland background wells (Lee-1 and -2) show the water quality to be similar except for the higher levels of combined Radium-226 + Radium-228 and gross alpha radiation detected at BG-03 and -04, and the higher selenium detected at BG-03 and BG-04.

The water quality results at BG-03, BG-04, and BG-05 in the upper SMC Basin represent a different hydrogeologic setting than the central and lower portion of the basin, and for this reason it may not be appropriate to do a comparative assessment to water quality data in those areas of the basin to assess if potential impacts from legacy uranium mine and mill sources have occurred. The different hydrogeologic settings are a result of differing near-surface geology and mineralogy in those other parts of the basin. Since the geology and mineralogy vary significantly across the SMC Basin, the background water quality data may also vary significantly across the basin. At the scale of this investigation, the proper technical approach would be to collect background data from each distinct area if that is possible. Given the fact, based on exploratory drilling, that most of the alluvium in the western and northern portions of the SMC Basin is naturally unsaturated, an adequate number and spatial distribution of representative background water quality samples are unavailable for those areas of the basin.

A determination of natural background water quality for the alluvial aquifer in the central portion of the basin north of the HMC site was not undertaken as part of this phase of the SMC Basin groundwater investigation. Rather, this area of the basin was included as part of the Phase 2 ground water investigation. EPA installed and sampled several alluvial monitoring wells north of the HMC site in 2015 as part of Phase 2. The results of this work will be documented in a

Phase 2 ground water investigation report which is scheduled for completion in late 2016. Additionally, as discussed earlier in this report, EPA is currently working with HMC, NRC and NMED to evaluate background water quality of the alluvial aquifer in this area of the basin and will be collecting additional groundwater data in 2016 with support of the USGS.

### 6.2.2 Monitoring Wells Downgradient of Potential Legacy Mine and Mill Sources

Alluvial monitor wells N-3A, MW-35-8, MW-35-9, and C-3 were sampled to provide alluvial groundwater quality data in locations downgradient of legacy uranium mines and mills and compare the downgradient groundwater quality data to EPA drinking water standands and NMWQCC groundwater standards as well as background water quality data to document a potential CERCLA release.

The results of the Phase 1 groundwater investigation show no significant alluvial saturation upgradient of wells N-3A, MW-35-8 and MW-35-9 due to insufficient natural recharge on the northern and western margins of the basin. Therefore, comparisons to up-gradient background water quality data within those specific tributary drainages cannot be made. The only recent alluvial groundwater quality data available for areas of the basin upgradient to legacy uranium mines and mills is the upland area near the village of San Mateo and Mount Taylor (*i.e.,* current data from wells BG-03, -04 and -05 wells). ~~As discussed earlier in this report, it may not be appropriate to make such comparision to these data due to potential differences in the geology and mineralogy for the N-3A, MW-35-8 and MW-35-9 areas and the uncertainty of the groundwater at the BG-03, 04-, AND -05 wells being unimpacted by the Mount Taylor Mine. The same goes for any comparison of ground water quality data from Well C-3 to the BG-03, -04 and -05 upland wells. However, since there are no other appropriate alluvial groundwater quality data available that would represent upgradient natural background water quality, a comparison will nevertheless be made with the recognition that additional lines of evidence will be needed to support a release determination.~~ A summary of the sample analytical results along with the standards and water quality data from the BG-03, -04, and -05 upland wells are presented in Table 6-3, below, for comparative purposes. The sample analytical results for N-3A, MW-35-8 and -9, and C-3 are also depicted on Figure 6-1.

**Table 6-3**
**Alluvial Groundwater Results**
**Monitoring Wells Downgradient of Potential Legacy Uranium Mine and Mill Sources**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Analyte | N-3A | C-3 | MW-35-8 | MW-35-9 | EPA or NMWQCC Standard | BG-03, BG-04, and BG-05 |
|---|---|---|---|---|---|---|
| Sulfate (mg/L) | 6300 | 1200JH | 2100 | 2800 | 600 | 13-76 |
| Total Uranium (mg/L) | 0.039 | 0.110 | 0.015 | 0.046 | 0.030 | 0.0027-0.016 |
| Total Dissolved Solids (mg/L) | 10000 | 2200 | 3600 | 4600 | 1000 | 310-620 |
| Total Radium (Ra-226+Ra-228 pCi/L) | 0.192 | 0.727 | 0.196 | 0.688 | 5 | 0.049-4.98 |
| Gross Alpha (pCi/L) | 52.9UG | 141G | 17.6UG | 49.6G | 15 | 13.5-51.0 |
| Total Selenium (mg/L) | 0.088JQ | 0.290 | 0.021U | 0.021U | 0.050 | <0.021U-0.023 |

Notes: mg/L – milligrams per Liter; pCi/L – picocuries per Liter; JQ – Analyte was detected at less than the reporting limit; G- the Sample MDC is greater than the requested RL; K – unknown bias; H- high bias; U-analyte not detected above method detection limit.

A comparision of the water quality data at N-3A, C-3, MW-35-8 and MW-35-9 to downgradient natural background water quality was not done for the Phase 1 groundwater investigation. As discussed in Section 3.44 of this report, HMC has determined background alluvial water quality north and upgradient of the LTP with respect to the HMC NPL site and site standards have been adjusted by the NRC under an amendment to License SUA-1471 to reflect background water quality (see Table 3-2). The background levels established by HMC for the COPCs are significantly higher than the concentrations at the upland wells BG-03, BG-04 and BG-05 and HMC has concluded that they represent natural background (HMC 2004 Background Report;

2015 Annual Report). As discussed above, EPA is continuing to reassess alluvial groundwater quality north of the LTP to determine if the HMC background levels are appropriate.

The following subsections describes COPCs reported above EPA MCLs and NMWQCC groundwater standards in samples collected from alluvial monitor wells N-3A, MW-35-8, MW-35-9, and C-3 and compares the sample data to the upland alluvial monitoring wells BG-03, BG-04 and BG-05.

### 6.2.3 Total Uranium Exceedances

As illustrated in Table 6-3 and Figure 6-1, total uranium was reported above the EPA MCL of 0.03 mg/L in wells N-3A, MW-35-9, and C-3. The maximum total uranium result was noted in well C-3 (0.11 mg/L), which is greater than three times the maximum concentration of 0.016 mg/L detected in wells BG-03, -04 and -05. Well C-3 is located adjacent to the San Mateo Creek and approximately 2.5 miles south of the junction of New Mexico State Highways 605 and 509. Well C-3 is located downgradient from most of the legacy uranium wet mines that operated in the SMC Basin.

### 6.2.4 Total Selenium Exceedances

Total selenium was reported above the EPA MCL of 0.050 mg/L in wells N-3A (0.088 mg/L) and C-3 (0.290 mg/L). No selenium was detected in wells MW-35-8 and MW-35-9 above the laboratory Method Detection Limit of 0.021 mg/L. The selenium concentration at N-3A is more than three times the maximum concentration of 0.023 mg/L detected at the BG-03, -04, and -05 wells. The selenium concentration at C-3 is more than 10 times the maximum concentration at those wells.

### 6.2.5 Total Dissolved Solids Exceedances

TDS concentrations exceeded the EPA Secondary MCL of 500 mg/L and the NMWQCC groundwater standard of 1,000 mg/L in wells N-3A (10,000 mg/L), MW-35-8 (3,600 mg/L), MW-35-9 (4,600 mg/L), and C-3 (2,200 mg/L). The TDS concentrations in all four wells were more that three times the maximum concentration of 620 mg/L detected at the BG-03, -04, and -

05 wells. The TDS concentration at N-3A was more than 10 times the maximum concentration at those wells.

TDS concentrations are comparatively low in the upper SMC Basin near the village of San Mateo (at BG-03, BG-4, BG-05), and generally increase moving east and south. The low TDS concentrations in this area are consistent with previous observations and suggest a relatively low-residence time in the subsurface of snowmelt and rainwaters from Mount Taylor as reported by the USGS. The highest TDS concentration was measured at well N-3A in the Ambrosia Lake area where much of the alluvium appears to be dry (based on borehole drilling), with the exception of the area near the former Rio Algom Mill Site.

### 6.2.6 Sulfate Exceedances

Concentrations of sulfate exceeded the EPA Secondary MCL of 250 mg/L and the NMWQCC groundwater standard of 600 mg/L in wells N-3A, MW-35-8, MW-35-9, and C-3 with the concentrations ranging from 1,200 in well C-3 to the maximum concentration of 6,300 mg/L in well N-3A. Well N-3A had the highest concentrations of both sulfate and TDS. Monitoring wells MW-35-8 and MW-35-9, located approximately one mile downgradient of the Section 35 and Cliffside mines, had the next highest sulfate levels at 2,100 and 2,800 mg/L, respectively, as well as high TDS levels (3,600 and 4,600 mg/L respectively). The sulfate concentrations for all four wells are more than 10 times the maximum concentration of 78 mg/L detected in wells BG-03, BG-04 and BG-05. Sulfate ions comprise the majority of the TDS.

### 6.2.7 Combined Radium-226 + Radium-228 Exceedances

For combined Radium-226 + Radium-228, there were no exceedances of the EPA MCL of 5.0 pCi/L in monitoring wells N-3A, MW-35-8, MW-35-9, and C-3. Concentrations reported for these wells ranged from 0.090 to 0.727 pCi/L and are within the range of concentrations detected at wells BG-03, BG-04 and BG-05 (0.049 to 4.98 mg/L).

### 6.2.8 Gross Alpha Exceedances

Gross alpha levels detected in monitoring wells MW-35-9 (49.6 pCi/L) and C-3 (141 pCi/L) were above the EPA MCL of 15 pCi/L. These levels were not greater than three times the maximum level of 51.0 pCi/L detected in wells BG-03, BG-04 and BG-05. The two samples collected from wells N-3A and MW-35-8 did not report detectable amounts of gross alpha radiation. At well N-3A and MW-35-8 levels of gross alpha were less than the laboratory method detection limits of 52.9 pCi/L and 17.6 pCi/L, respectively. These method detetion limits from dilutions are noted to be above the EPA MCL of 15 piC/L. The possibility exists that gross alpha is present at or above the EPA MCL at these locations.

### 6.2.9 General Chemistry

Cation and anion data for the water samples collected during Phase 1 were normalized and plotted on Trilinear Diagrams (Figure 6-2) using the USGS Groundwater Chart Program. The cation and anion data indicate two major water types for the SMC Basin alluvial groundwater samples: Ca-HCO3 water type in the north eastern portion of the basin, and Na/Mg-SO4 water type in the northwestern, central, and southern parts of the basin.

Water sample major ion chemistry represented by BG-03, BG-04, and BG-05 displays TDS concentrations that are an order of magnitude lower than the rest of the alluvial sample results. The overall increase in TDS and a Na-SO4 water type at other alluvial sample locations may reflect a difference in geologic conditions, mineralogy of the aquifer sediments, and surface hydrology. The groundwater residence time at other locations may be much greater than the short time of residence near Mount Taylor. A longer groundwater residence time increases the concentration of dissolved solutes as water moves along a flow path. This occurs in natural, arid systems, but may be exacerbated by groundwater and/or meteoric water percolating through mine wastes.

The increase in TDS and Na-SO4 water type may also reflect anthropogenic impacts on the general chemistry by legacy uranium mines and mills. As discussed in Section 4.4 (Historical Alluvial Water Quality), Brod and Stone (1981) and Gallaher and Cary (1985) report high levels of TDS and sulfate in mine water discharges and alluvial groundwater. Kaufmann and others (1975) report an increase of TDS and other constituents in alluvial groundwater below the confluence of Arroyo del Puerto and San Mateo Creek.

### 6.2.10 Stable Isotopes

Stable isotope analyses, presented in Table 6-4, were performed on a subset of the groundwater samples (PV-03F, PV-03UF, and PV-03 DW). Lightweight stable isotopes, including the hydrogen-deuterium system ($\delta D$), the oxygen-18/16 system ($\delta^{18}O$), the carbon-13/12 system ($\delta^{13}C$), and the sulfur-34/32 system ($\delta^{34}S$), fractionate readily at surface temperatures and pressures, and are commonly used to assist with the differentiation of water sources. Results are presented as deviation, on a per thousand basis (known as per mille), from published standards, including Standard Mean Ocean Water (SMOW) for deuterium and oxygen, PeeDee belemenite (PDB) for carbon, and troilite (iron sulfide mineral) extracted from the Canyon Diablo meteorite (CDT).

Results for $\delta D$ range from -66.3 to -87.6 o/oo, and $\delta^{18}O$ results range from -9.09 to -12.21 o/oo, indicating depletion of the heavier isotopes with respect to SMOW. Results for $\delta^{13}C$ range from 7.9 to -13.1 o/oo, indicating depletion of carbon with respect to the PDB standard. Results are consistent with the range of meteoric waters for the latitude of the study area (Faure, 1986).

Results for $\delta^{34}S$ range from 15.0 to -22.0 o/oo with respect to the CDT standard. The wide range of deviation from the standard suggests a wide range of provenance of the sulfur in the water, which may include terrestrial and marine sediments, and/or hydrothermal deposits. Sulfur-reducing bacteria, however, can play a significant role in $\delta^{34}S$ fractionation in near-surface conditions. Additional data are necessary to make any kind of definitive conclusion from these $\delta^{34}S$ isotope analyses.

There are not enough data points or confidence in the screening intervals of the subject wells to make any more definitive statements about the different stable-isotope values with respect to water sources and their geochemical history for Phase 1.

**Table 6-4**
**Stable Isotopes**
**San Mateo Creek Basin Uranium Legacy Site**
**Cibola and McKinley Counties, New Mexico**

| Analyte | Units | Location<br>Sample ID<br>Date<br>Type | PV03<br>PV03-20150716-21DW<br>7/16/2015<br>Field Sample | PV03<br>PV03-20150716-21F<br>7/16/2015<br>Field Sample | PV03<br>PV03-20150716-21UF<br>7/16/2015<br>Field Sample |
|---|---|---|---|---|---|
| **Stable Isotopes** | | | | | |
| $\delta^{34}S\ SO_4^{2-}$ | ‰ | -- | **-1.6** | **-1.4** | **-1.5** |
| $\delta^{13}C$ DIC | ‰ | -- | **-8.5** | **-8.3** | **-8.7** |
| $\delta^{18}O\ H_2O$ | ‰ | -- | **-9.94** | **-9.84** | **-9.68** |
| $\delta D\ H_2O$ | ‰ | -- | **-74.5** | **-74** | **-74.4** |

### 6.2.11 Mineralogy

Mineralogical analysis was performed on six sediment core samples collected from near the base of the alluvium in boreholes C-3 (85 ft. depth), C-5B (40 ft. depth), N-5 (32 ft. depth), N-1 (47 ft. depth), N-2 (24 ft. depth), N-4 (91 ft. depth) and BG-07 (55 ft. depth). The results from the six samples submitted for quantitative mineralogical analyses are presented in Appendix O. All samples submitted are clastic sedimentary deposits, ranging from clay-rich to clay-poor consistency. Total clay concentration ranges from 4 to 48% across the sample suite, with smectite and kaolinite at sub-equal concentrations with subordinate illite. The clay mineral assemblage suggests a heavily recycled igneous provenance for these sediments.

The medium and coarse fraction ranges from quartz-feldspathic to quartz-carbonate mineral assemblage; the latter may suggest either a near-source carbonate provenance, such as carbonate clasts from the upper Chinle Formation or, just as likely, secondary precipitate mineralization.

Goethite [FeO(OH)] is a trace phase in about half of the samples. It is a relatively common resistant opaque oxide phase in clastic sediments, commonly further oxidizing to hematite [$Fe_2O_3$], which is present at trace concentrations in sample C-3.

Gypsum [$CaSO_2(H_2O)$] is present as a significant phase in sample C-5, which is also the highest clay content; gypsum in this sample is most likely a secondary phase due to its high solubility and softness.

Jarosite [$KFe_3(OH)_6(SO_4)$] is present at trace quantities in sample N-5. It is a common breakdown product of sulfide minerals and may represent circumstantial evidence of the presence of mine waste.

The presence of carbonate and sulfate minerals in these samples is consistent with an arid depositional environment, where carbonate-bicarbonate and sulfate readily move back and forth between aqueous and solid phases as local water approaches saturation for these constituents.

Sediments high in clay minerals often have a high organic content, which can reduce and solidify aqueous uranium. In addition, clay fractions also commonly contain trace quantities of uranophyllic phases, such as apatite and zircon, which produce uranium daughter products on decay.

### 6.2.12 Soil SPLP

In areas where groundwater was not encountered at-depth, soil samples were collected from selected borings (BG-07-55 feet, C-5B-40 feet, N-1-47 feet, N-2-24 feet, N-4-91 feet, and N-5-32 feet) for SPLP general chemistry, metals, and radiological analyses. The objective of submitting at-depth soil samples to a synthetic leaching procedure was to identify COPCs that may have leached (or will leach) into the soil as a result of historical mine water discharge.

In review of the six soil samples for SPLP analyses, the data appear to be inconclusive with respect to identifying historical mine waste COPCs in the alluvial water-bearing zone. Total uranium was not reported above the detection limit in any of the samples submitted; however, the reported method detection limit (MDL) range was 0.026 mg/L to 0.26 mg/L, with all but one of the MDLs being higher than the MCL of 0.03 mg/L. Some radiological detections, including Uranium-233/234, were reported in samples C5-B (collected at 40 feet bgs), N2 (24 feet bgs), and N5 (32 feet bgs). Uranium-238 was noted in soil samples C-5B (40 feet) and N5 (32 feet bgs). Thorium-228, Thorium-230, and Thorium-232 isotope detections were reported for the N-5 soil sample.

The low uranium concentrations in non-saturated soils are consistent with the high solubility of uranium in an oxidizing environment. Uranium in an oxidized valence state is prone to remain in solution and migrate in the direction of water flow. Lower detection limits might improve the analytical results for reportable uranium levels, but the general observation is that the sediments at these locations and depths probably do not yield significant uranium to groundwater.

Sulfate concentrations mostly range from <0.05 to 19 mg/L in the SPLP sample suite, with the anomalous exception of sample N-5, with a sulfate concentration of 1,700 mg/L. Sample N-5 also has anomalously high calcium and magnesium concentrations, suggesting a high precipitate concentration in this soil sample.

## 6.3 PRIVATELY-OWNED WELLS SAMPLED

For the purposes of this report and based on the objectives of the investigation, the results summary focused on COPCs in the newly installed alluvial monitoring wells and those industry monitoring wells known to be completed in the alluvial water-bearing zone (Tables 6-2 and 6-3). There is uncertainty with the remaining 13 privately-owned water wells[7] sampled by START-3 regarding the well completion depth, screened interval, and construction to make a confident determination if the groundwater sampled is from the alluvium or other bedrock water-bearing units such as the Upper-Middle-Lower Chinle, Morrison, and San Andreas/Glorieta formations. There is a high probability that a number of these wells may be screened over one or more water-bearing units. START-3 researched the New Mexico Office of the State Engineer (OSE) database for well drilling reports and coordinates to verify well location, screened interval, and well depth. Interviews of the respective well owners was also conducted to verify well depth,

[7] Some water wells that were once privately owned in the vicinity of the HMC NPL site are now owned by HMC and used for monitoring groundwater quality. Well 907, which is owned by the Village of Milan, is also used by HMC for monitoring.

construction, and groundwater use. Table 6-6, as well as Figure 6-2, include the 13 privately-owned water wells sampled by START-3.

START-3 sampled wells included 907, 928, 943, PV-01, PV-02, PV-03, SMC-09, SMC-10, SMC-11, SMC-12, SMC-13, SMC-14, and SMC-26 as part of the field investigation activities. All 13 wells exceeded NMWQCC groundwater standards and/or the EPA National Primary and Secondary Drinking Water Standard MCLs for one or more analytes. Wells 907, 928, 943, PV-01, SMC-10, SMC-11, SMC-12, SMC-13, and SMC-14 exceeded the EPA Secondary MCL for sulfate of 250 mg/L. All wells, except for PV-02 and PV-03, exceeded the EPA Secondary MCL for TDS of 500 mg/L. Wells 928, PV-03, SMC-11, SMC-12, SMC-13, and SMC-26 exceeded the EPA MCL of 0.03 mg/L for total uranium. NMWQCC exceedances for dissolved uranium above 0.03 mg/L were observed in wells PV-03 (except for PV-03-DW sample), SMC-11, SMC-12, SMC-13, SMC-26, 928, and 943. Gross alpha results exceeded the EPA MCL of 15 piC/L for all wells except for wells PV-01, PV-02, SMC-10, and SMC-14. There were no EPA MCL exceedances above 5 piC/L for combined Radium-226 and Radium-228 in any of the START-3 sampled well results. The laboratory results for these wells are included in Figure 6-3 and Table 6-6.

# 7 CONCLUSIONS

Based on the findings of the Phase 1 groundwater investigation, the following conclusions can be made:

1. Alluvial sediments in the northern and western upland areas of the San Mateo Creek basin (SMC Basin) are mostly dry with the exception of an isolated area near the Rio Algom Mill Site along Arroyo del Puerto and a second area south of the Section 35 and Cliffside mines. Based on extensive borehole drilling, the saturation within the alluvial sediments along Arroyo del Puerto does not appear to be hydraulically connected with the alluvial aquifer beneath San Mateo Creek at the confluence of the two drainages. It is not known whether the second area of alluvial saturation is hydraulically connected to the San Mateo Creek alluvial aquifer. The lack of alluvial saturation in the upland areas prevented the collection of groundwater samples along tributary drainages upgradient of the legacy mines and mills in the Ambrosia Lake area. Therefore, a determination of natural alluvial background water quality in this area was not possible.

2. Significant alluvial saturation was encountered in the northeast part of the SMC Basin near the village of San Mateo and the western flank of Mount Taylor. Monitoring of groundwater quality from upland wells BG-03, BG-04, and BG-05 showed concentrations of the contaminants of potential concern (COPCs) were below EPA MCLs and NMWQCC ground water standards for all contaminants of potential concern (COPCs) with the exception of gross alpha at wells BG-03 and BG-04. Combined Radium-226 + Radium-228 in these two monitoring wells was an order of magnitude higher than BG-05, but the levels were still below the EPA MCL. Groundwater samples collected from these wells were expected to represent background water quality, but because of the elevated radium and gross alpha levels, it is uncertain whether the alluvial water quality has been impacted by the nearby Mount Taylor Mine.

3. Alluvial groundwater samples collected from all of the wells downgradient of legacy uranium mines and mills had concentrations of COPCs which exceeded EPA MCLs and

NMWQCC groundwater standards. In comparing the sample results from these wells to the alluvial water quality at the upland monitoring wells BG-03, BG-04 and BG-05, the concentrations of uranium, selenium, TDS and sulfate in certain downgradient wells were greater than three times the concentrations of the upland wells. Sulfate concentrations in all four downgradient wells were 10 times higher than sulfate levels at the upland wells and the TDS concentration at N-3A was 10 times higher than the upland wells.

4. ~~A determination of a release as defined under CERCLA Section 101(22), which was an objective of Phase 1, will not be made based on the findings of this report.~~ The inability to determine natural background water quality for the alluvium in various parts of the SMC Basin and the recognition that alluvial background water quality is likely to vary across the basin due to differences in the geology and mineralogy provides a level of uncertainty in making such a determination. ~~As stated in this report, the comparison of sample data from wells downgradient of the legacy mine and mill sites to the alluvial water quality in only one area of the basin – the upland area wells BG-03, BG-04 and BG-05 near the village of San Mateo – is not adequate for a CERCLA release determination without other lines of evidence.~~ EPA continues to investigate groundwater impacts in Phase 2. EPA is also reassessing alluvial background water quality at the HMC NPL site. ~~The results of those investigations or other future studies may provide the information necessary for EPA to document a release to groundwater from legacy uranium mines within the basin.~~

5. Alluvial groundwater at wells N-3A near the Rio Algom Mill Site and MW-35-8 and MW-35-9 south of the Section 35 and Cliffside mines was of the poorest quality measured during Phase 1 based on TDS and sulfate levels. A comparision of sample data from these wells to historical data of the 1981 mine water discharges for the Ambrosia Lake area and San Mateo Creek area shows that the TDS and sulfate levels are similar and consistent with the findings of Brod and Stone (1981).

6. Mine water discharges resulted in the saturation or resaturation of alluvial sediments along the Arroyo del Puerto and San Mateo Creek channels on a very large scale with

water levels in the central part of the basin (in the vicinity of the Otero well cluster and Well C-3) being raised approximately 55 feet by 1977. This is evident by static water level measurements at Well C-3 in 2015, which are now about 55 feet lower than those recorded at the nearby Otero well cluster in 1977. The drop in the C-3 water level indicates a dramatic decline in the alluvial saturated thickness since 1977 in response to the cessation of mine water discharge within the basin. It appears that mine discharge water that saturated alluvial sediments during the peak mining period has mostly drained out of the alluvium in the northern and central parts of the SMC Basin. The draindown observed at Well C-3 in the central part of the basin is not evident in monitoring wells located downgradient at the Homestake Mining ~~Companhy~~ Company (HMC) NPL site, a distance of approximately three miles. The static water level elevations measured at HMC monitoring well R have actually increased slightly (3-4 feet) since the mid-1990s.

7. The two areas of alluvial saturation in the Ambrosia Lake area and south of the Section 35 and Cliffside mines, with similar poor water quality as historical mine water discharges with respect to TDS and sulfate, may represent residual pockets of mine water that may be draining into underlying bedrock formations.

8. Groundwater samples collected from the thirteen private waterwells (alluvial and bedrock wells) exceeded EPA MCLs and/or NMWQCC groundwater standards for one or more COPCs. Wells 928, PV-03, SMC-11, SMC-12, SMC-13, and SMC-26 exceeded the EPA MCL for total uranium.

9. Additional data are needed to make any definitive conclusions about the different stable isotope values. EPA has collected additional isotopic data (stable isotopic and radiolocal isotopic data) from monitoring wells as part of the ongoing Phase 2 groundwater investigation.

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